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LUNDS ASTRONOMISKA OBSERVATORIUM

SERIE II

N:r 26

A RESEARCH ON MOVING CLUSTERS

BY

NILS H. RASMUSON

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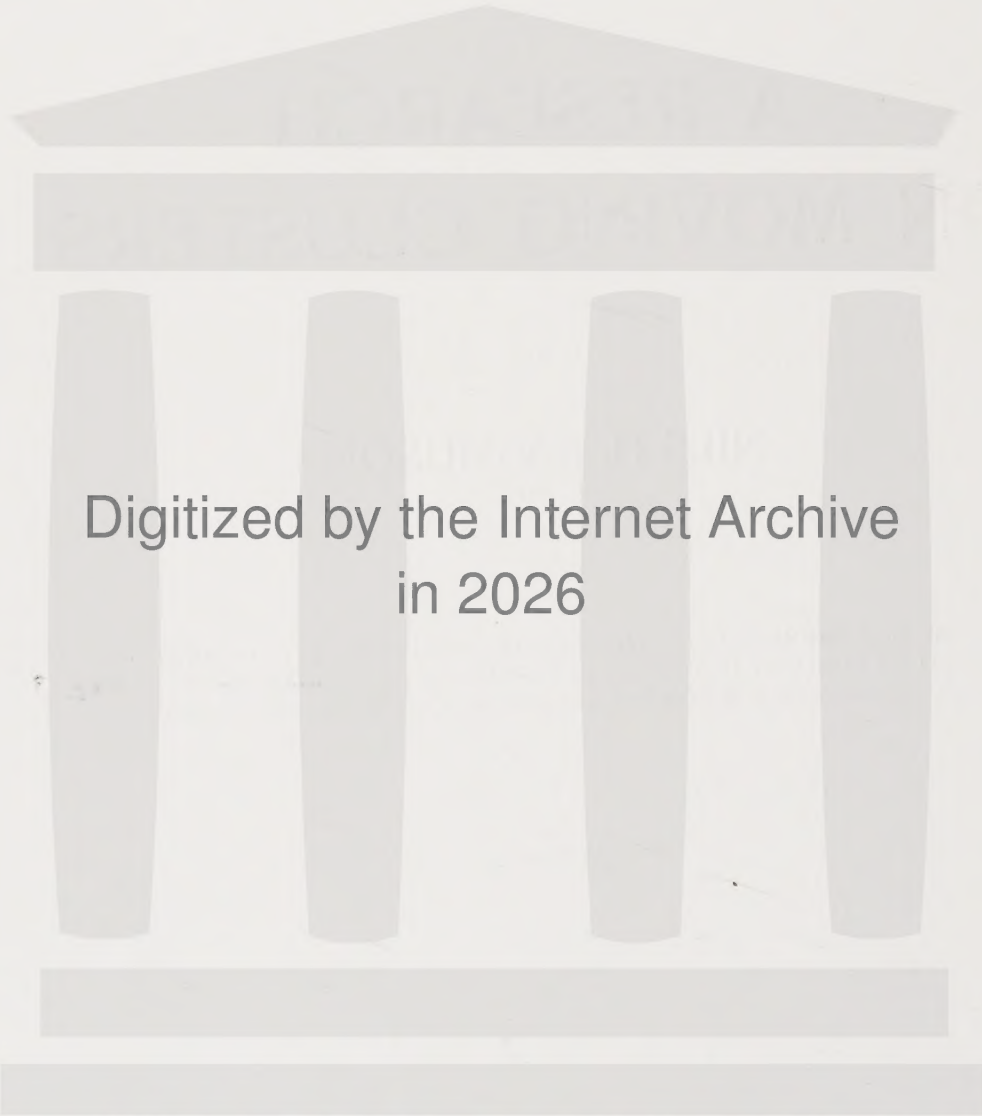


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INTRODUCTION.

On the basis of the ascertained laws of star-streaming, we are entitled to maintain that the universe has not yet reached a state of stability. JEANS⁶⁰ thus presumes that the universe, in the earlier stage of its evolution, consists of a chaos of compact moving star-clusters. In the present stage the star-streams have intermingled and are mixed with a large number of independent stars or runaways that will be increased more and more. Finally the star-streams will not be recognizable as such any more, but will have given place to a chaos of independently moving stars.

The effect of the forces from the stars in the whole universe on the stars in a fairly compact cluster is the same for each star in the cluster. The disintegration of the cluster then can be influenced in the main

- (1) by the forces from the rest of the stars in the cluster, and
- (2) by the forces acting from stars in clusters which are in collision with this cluster.

The former alone would spread out the cluster into infinite size, if they were allowed to act for a sufficient time. Comparing the universe of compact moving star-clusters with a rare gas whose molecules are star-clusters, a collision will take place, when the "molecules" are passing through one another. (Taurus may be an example of a molecule in collision.) The collisions or encounters between star-clusters have been studied thoroughly by JEANS with the following results.

In the special case of a head-on-encounter with a cluster of larger dimensions, the stars in the first cluster will scatter at right angles to the direction of the collision; thus the distribution of the stars in space will be changed, so that from being a point (approximately) the cluster will become a disc, normal to the relative velocity between the two colliding clusters. (In the actual problem the distribution will be not exactly in a plane, and the cluster will be in the shape of a lens or a biscuit rather than of a disc.) After a double encounter the distribution in the cluster will be an ellipsoid with the greatest semi-axes $a < \sqrt{b^2 + c^2}$. After a great number of encounters, with the relative velocities distributed at random, we get an oblate spheroid that will be very flat for a very rapidly moving cluster, but almost spherical for a slowly moving one. The effect on the larger cluster, as assumed above, will be a diminishing of the star density in the area effected by the passage of the smaller cluster and finally a hole in the larger cluster.

The disintegration of a star-cluster from its encounters with other stars or clusters may take a considerably long time. Assuming the density to be one star to a sphere with the radius one parsec. and the average mass of a star five times that of the solar system, JEANS has deduced the following numerical results. Take a moving cluster, all the stars of which have equal and parallel velocities of 40 km./sec., and let a star be considered to continue a member of the main stream as long as its direction of motion does not diverge by more than 2° . After 100 million years only one in 8000 of the

original members will be lost by violent encounters, and the remainder will make angles with the main stream of which the average amount will be only one minute. After 80000 million years one tenth of the original members will have been lost, but the average angle of the remainder will be 5° . Thus the stream has been dissolved mainly by gradual scattering and not by sharp encounters.

In the present paper I have made an investigation of known moving clusters with the intention,

- (1) to determine the convergent and the stream-velocity of the clusters;
- (2) to compute the parallaxes and the absolute magnitudes of the stars in the clusters;
- (3) to investigate the distribution in space of the stars.

I have also intended to give a brief review of the results of earlier investigations in this department.

ABBREVIATIONS.

Abbreviations of works consulted.

A. J.	The Astronomical Journal.
Ap. J.	The Astrophysical Journal.
A. N.	Astronomische Nachrichten.
L. M.	Meddelanden från Lunds astronomiska observatorium.
M. N.	Monthly notices of the Royal Society in London.
M. W.	Mount Wilson Contributions.
G. P.	Groningen Publications.
L. O. B.	Lick Observatory Bulletin.
R. A. S.	Royal Astronomical Society.
A. S. P.	Astronomical Society of the Pacific.
C. C.	The card-catalogue, Observatorium Lund.
Stockh.	Astronomiska iakttagelser och undersökn. vid Stockholms observatorium.

Abbreviations in the tables.

P. G. C.	Preliminary General Catalogue of Boss.
α, δ	Equatorial coordinates.
u, v	Proper motions.
Sp.	Spectral-type (Harvard).
m, M	Apparent (Harvard) and absolute magnitude.
w, w_c	Observed and computed radial-velocity.
π, π_c	» » » parallax.
q, q_c	» » » position-angle.
r	Distance in siriometer, λ angular distance from the convergent.
x, y, z	Rectangular galactic coordinates (siriometer).

Radial-velocities (Voûte).

A Allegheny, B Bonn, C Cape, c Cambridge, D Detroit, h Heidelberg, L Lick, l Lowell, m Mc Millan, O Ottawa, P Potsdam, p Pulcowa, W Mount Wilson, w Wien, Y Yerkes.

Parallaxes.

A Allegheny, D Dearborn, F Flint, G Groningen, J Jewdokimow, Jo Jost, K Kapteyn, Ky Kostinsky, M Mitchell, Mc McCormick, Lu Ludendorff, P Pritchard, R Russell, S Sproul, Sl Slocum, Sm Smith (Yale), V Voûte, W Mt. Wilson, Y Yale, Ye Yerkes.

The parallaxes bracketed are spectroscopic parallaxes from Adams and Joy.

CHAPTER I.

In this chapter I will give a recapitulation of the formulas.

A. THE DETERMINATION OF THE CONVERGENT.

Two methods have been used, the first suitable for the calculating machine, the second for calculations with logarithmic tables.

The first method has been given by CHARLIER²⁸.

I. Let U, V, W denote the components of the velocity of a star in a system of right angles coordinates having its axes of $Z(W)$ directed along the radius vector, the axis of X in the direction of increasing α , the axis of Y in the direction of increasing δ . Let further U'', V'', W'' denote the components of the velocity of the same star referred to the common astronomical equator-system.

Then we have:—

$$(1) \quad \begin{aligned} U &= \gamma_{11} U'' + \gamma_{21} V'' + \gamma_{31} W'', \\ V &= \gamma_{12} U'' + \gamma_{22} V'' + \gamma_{32} W'', \\ W &= \gamma_{13} U'' + \gamma_{23} V'' + \gamma_{33} W'', \end{aligned}$$

where:—

$$\begin{aligned} \gamma_{11} &= -\sin \alpha, & \gamma_{21} &= +\cos \alpha, & \gamma_{31} &= 0, \\ \gamma_{12} &= -\sin \delta \cos \alpha, & \gamma_{22} &= -\sin \delta \sin \alpha, & \gamma_{32} &= +\cos \delta, \\ \gamma_{13} &= +\cos \delta \cos \alpha, & \gamma_{23} &= +\cos \delta \sin \alpha, & \gamma_{33} &= +\sin \delta. \end{aligned}$$

If $u = \Delta \alpha \cos \delta$, $v = \Delta \delta$ denote the proper motion of the star we have:—

$$U = r \cdot u, \quad V = r \cdot v, \quad W = \text{the radial-velocity.}$$

Multiplying the first equation in (1) by v and the second by u and subtracting:—

$$\begin{aligned} U''(\gamma_{12} \cdot u - \gamma_{11} \cdot v) + V''(\gamma_{22} \cdot u - \gamma_{21} \cdot v) + W''(\gamma_{32} \cdot u - \gamma_{31} \cdot v) &= 0, \\ a \cdot U'' + b \cdot V'' + c \cdot W'' &= 0, \end{aligned}$$

or

$$(2) \quad \begin{cases} a \cdot \alpha + b \cdot \beta + c \cdot \gamma = 0, \\ \alpha^2 + \beta^2 + \gamma^2 = 1, \end{cases}$$

where:—

$$\begin{aligned} U'' &= \Omega \cos A \cos D = \Omega \cdot \alpha, \\ V'' &= \Omega \sin A \cos D = \Omega \cdot \beta, \\ W'' &= \Omega \sin D = \Omega \cdot \gamma, \end{aligned}$$

and:—

$$\begin{aligned} a &= \gamma_{12} \cdot u - \gamma_{11} \cdot v, \\ b &= \gamma_{22} \cdot u - \gamma_{21} \cdot v, \\ c &= \gamma_{32} \cdot u. \end{aligned}$$

Putting $\frac{\alpha}{\gamma} = x$, $\frac{\beta}{\gamma} = y$, we get equations of the form

$$ax + by + c = 0,$$

which are solved by the method of the least squares from the following system of equations.

$$\begin{aligned} [aa]x + [ab]y + [ac] &= 0, \\ [ab]x + [bb]y + [bc] &= 0. \end{aligned}$$

We then have the coordinates of the convergent (A, D)

$$\begin{aligned} \operatorname{tg} A &= \frac{y}{x}, \\ \sin D &= \gamma = \sqrt{\frac{1}{x^2 + y^2 + 1}}. \end{aligned}$$

The mean error in x ($\varepsilon(x)$) and y ($\varepsilon(y)$) calculated, we get the mean error of A and D thus:—

$$\begin{aligned} \varepsilon(A) &= 57.3 \cdot \frac{\cos^2 A}{x^2} \cdot \sqrt{x^2 \varepsilon^2(y) + y^2 \varepsilon^2(x)}, \\ \varepsilon(D) &= 57.3 \cdot \frac{1}{\cos D} \cdot \sqrt{\frac{x^2 \varepsilon^2(x) + y^2 \varepsilon^2(y)}{(x^2 + y^2 + 1)^{\frac{3}{2}}}}. \end{aligned}$$

The mean error can also be computed from the mean error in the position-angle q .

$$\begin{aligned} \varepsilon(D) &= \sin \lambda \cdot \varepsilon(q), \\ \cos D \cdot \varepsilon(A) &= \varepsilon(D). \end{aligned}$$

The stream-velocity Ω is computed from the equation

$$\begin{aligned} W &= (\gamma_{13} \cdot \alpha + \gamma_{23} \cdot \beta + \gamma_{33} \cdot \gamma) \cdot \Omega = d \cdot \Omega, \\ (3) \quad \Omega &= \frac{[d W]}{[d d]}, \\ \varepsilon(\Omega) &= \frac{\varepsilon(W)}{V[d d]}. \end{aligned}$$

The radial-velocities W are to be corrected by means of the value of the K -term from GYLLENBERG⁴⁸ for the different spectral-types, namely for $B_0 - B_5: K = 0.91$, for $B_8 - B_9: K = 0.26$.

The second method has been given by BOHLIN¹⁰ and used by the author in a preceding paper¹⁰⁰.

II. Let A', D' denote the coordinates of the poles of the great circles along which the stars are moving, q the position-angle, λ the angle between the star and the convergence point (A, D) and μ the proper motion, we then have the following system of equations:—

$$\begin{aligned} (4) \quad & -\cos(A - A') = \operatorname{tg} D \operatorname{tg} D', \\ & -\operatorname{tg} D' = x \cos A' + y \sin A'; \\ & x = \cot D \cos A, \\ & y = \cot D \sin A; \\ & \cos D' \sin(\alpha - A') = \cos q, \\ & \sin D' \sin(\alpha - A') = -\sin \delta \sin q, \\ & \sin D' = \cos \delta \sin q; \end{aligned}$$

$$\begin{aligned}
 \mu \cos D' \sin(\alpha - A') &= v, \\
 \mu \cos D' \cos(\alpha - A') &= -u \sin \delta, \\
 \mu \sin D' &= u \cos \delta; \\
 \sin \lambda \sin q &= \cos D \sin(\alpha - A), \\
 -\sin \lambda \cos q &= \sin D \cos \delta - \cos D \sin \delta \cos(\alpha - A), \\
 \cos \lambda &= \sin D \sin \delta + \cos D \cos \delta \cos(\alpha - A); \\
 \cos D \cos(\alpha - A) &= m \sin M, \\
 \sin D &= m \cos M; \\
 \sin \lambda \sin q &= \cos D \sin(\alpha - A), \\
 -\sin \lambda \cos q &= m \cos(\delta + M), \\
 \cos \lambda &= m \sin(\delta + M).
 \end{aligned}
 \tag{4}$$

We then get equations of the form

$$-\operatorname{tg} D' = x \cos A' + y \sin A',$$

which may be solved by means of the method of the least squares by the following system of equations:—

$$\begin{aligned}
 [a a]x + [a b]y + [a n] &= 0, \\
 [a b]x + [b b]y + [b n] &= 0,
 \end{aligned}$$

where $a = \cos A'$, $b = \sin A'$, $n = \operatorname{tg} D'$.

The convergent is corrected for the solar motion, assuming the position of the apex at

$$A = 270^\circ, D = 30^\circ,$$

and the velocity of the sun = 20 km./sec.

Denoting by A, D, Ω the coordinates of the apparent motion and by A_0, D_0, Ω_0 the coordinates of the absolute motion, we then have

$$\begin{aligned}
 \Omega_0 \cos A_0 \cos D_0 &= \Omega \cos A \cos D, \\
 \Omega_0 \sin A_0 \cos D_0 &= \Omega \sin A \cos D - 17.320, \\
 \Omega_0 \sin D_0 &= \Omega \sin D + 10.000.
 \end{aligned}$$

B. THE DETERMINATION OF THE PARALLAXES AND THE ABSOLUTE MAGNITUDES OF THE STARS.

From the stream-velocity Ω in sirimeters pro stellar-year the distance r is computed in sirimeters by the formula

$$r = \frac{\Omega \sin \lambda}{4.8481 \cdot \mu},$$

$$1 \text{ sir./st.} = 4.7375 \text{ km./sec.},$$

$$1 \text{ stellar-year} = 10^6 \text{ tropic years},$$

and the parallax

$$\pi = \frac{0''.206265}{r}.$$

From the distance r and the apparent magnitude m the absolute magnitude M is computed by means of the formula

$$M = m - 5 \log r.$$

(M = the apparent magnitude at the distance of 1 siriometer which corresponds to a parallax of $0''.206265$.)

$$\text{The mean absolute magnitude} = M_0 = \frac{\sum M}{n}.$$

The dispersion in absolute magnitude:—

$$\sigma = \sqrt{\frac{\sum (M - M_0)^2}{n}}.$$

C. THE DETERMINATION OF THE DISTRIBUTION OF THE STARS AND THE DIRECTION OF THE ELLIPSOIDAL AXES.

The equatorial coordinates (α, δ) are transformed into galactic coordinates (l, b) by the formula of CHARLIER²⁹. The pole of the galactic plane has the coordinates:—

$$\alpha = 190^\circ, \quad \delta = +28^\circ.$$

Put

$$\begin{aligned} \xi'' &= \cos \delta \cos(\alpha + 80^\circ), \\ \eta'' &= \cos \delta \sin(\alpha + 80^\circ), \\ \zeta'' &= \sin \delta, \end{aligned}$$

let further ξ, η, ζ denote the spherical coordinates of a star referred to the galactic system, and we have

$$\begin{aligned} \xi &= \xi'' = \cos b \cos l, \\ \eta &= \eta'' \sin 28^\circ + \zeta'' \cos 28^\circ = \cos b \sin l, \\ \zeta &= -\eta'' \cos 28^\circ + \zeta'' \sin 28^\circ = \sin b, \end{aligned}$$

l, b being the galactic longitude and latitude reckoned from the ascending node. The coordinates in space are then

$$x = r \cdot \xi, \quad y = r \cdot \eta, \quad z = r \cdot \zeta.$$

In order to determine the distribution of the stars with the method given by CHARLIER²⁸ the moments around the origin are calculated:—

$$\begin{aligned} \nu'_{11} &= M(x^2), & \nu'_{22} &= M(y^2), & \nu'_{33} &= M(z^2), \\ \nu'_{12} &= M(xy), & \nu'_{13} &= M(xz), & \nu'_{23} &= M(yz), \end{aligned}$$

and from these the moments around the medium

$$\nu_{ij} = \nu'_{ij} - m_i m_j,$$

where m_1, m_2, m_3 denotes the mean value of x, y, z , and M the mean value of the quantities bracketed.

I then form the Jacobean equation of third degree

$$A = \begin{vmatrix} \nu_{11} - t, & \nu_{12}, & \nu_{13} \\ \nu_{21}, & \nu_{22} - t, & \nu_{23} \\ \nu_{31}, & \nu_{32}, & \nu_{33} - t \end{vmatrix} = 0.$$

From the value of t , I get, as has been shown by WICKSELL¹²², the dispersion in the coordinates along the three axes $\alpha_1, \alpha_2, \alpha_3$ from the equations

$$\begin{aligned} t_1 &= \alpha_1^2, \\ t_2 &= \alpha_2^2, \\ t_3 &= \alpha_3^2. \end{aligned}$$

Denoting by N the total number of the stars in the cluster, the density (stars pro cubicsirionometer) is

$$C = \frac{N}{\alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \sqrt{(2\pi)^3}},$$

and the frequency function takes the form

$$F = C \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{\alpha_1^2} + \frac{y_1^2}{\alpha_2^2} + \frac{z_1^2}{\alpha_3^2} \right)}.$$

The direction of the principal axes are determined with the help of the Jacobean equation:—

$$I = \begin{vmatrix} \nu_{11} - t_i, & \nu_{12}, & \nu_{13} \\ \nu_{21}, & \nu_{22} - t_i, & \nu_{23} \\ \nu_{31}, & \nu_{32}, & \nu_{33} - t_i \end{vmatrix}.$$

If I_{ij} denotes the subdeterminants, we have

$$\begin{aligned} l_i &= \frac{I_{11}}{\sqrt{I_{11}^2 + I_{12}^2 + I_{13}^2}} = \cos L \cos B, \\ m_i &= \frac{I_{12}}{\sqrt{I_{11}^2 + I_{12}^2 + I_{13}^2}} = \sin L \cos B, \\ n_i &= \frac{I_{13}}{\sqrt{I_{11}^2 + I_{12}^2 + I_{13}^2}} = \sin B. \end{aligned}$$

CHAPTER II.

THE TAURUS-CLUSTER.

(Fig. I.)

The existence of a great number of stars with associated proper motions in the region of the Hyades was first pointed out by PROCTOR⁹⁸. A detailed knowledge of this moving cluster has been ascertained by the researches of L. BOSS¹⁹. In order to determine the convergent he formed two series of equations of condition; the first determined a line in space along which the convergent should be found; the second fixed the point of convergence relative to two trial points selected on this line. Two successive approximations to the position of the convergent were computed. Before the last approximation two stars were excluded, P. G. C. 1025, with less well determined proper motions, and P. G. C. 1051, a double star. For the remaining 39 stars he computed the convergent

$$A = 6^{\text{h}} 7^{\text{m}}_2, D = +6^{\circ} 56' \text{ (1875)}$$

with the probable error in $A \pm 1^{\circ}$, in $D \pm 0^{\circ}.3$.

From the radial-velocity measured by KÜSTNER⁷⁶ for three stars, P. G. C. 1000, 1017, 1044, all of the later spectral type (G, K, K), namely $+39.6, +40.8, +39.4$ km./sec. he found the stream-velocity

$$\Omega = 45.6 \text{ km./sec.},$$

and the mean value of the parallax

$$\pi = 0''.025.$$

From these researches the Taurus-cluster appears to be a globular cluster with pronounced central condensation, with a diameter of about ten parsecs (2 sir.), when the apparent diameter is nearly 15 degrees. The brightness of the stars varies from 5 to 100 times that of the sun. Twenty-six of the stars have the spectral-type A .

The proper motions and the parallax of the Hyades have later been measured by KAPTEYN^{68, 69} and SITTER (from plates prepared by Donner und Küstner). Among stars from the 6th up to the 10th magnitude they considered 27 stars as "very probably" belonging to the stream, 19 "probably" and 16 "doubtful", and as mean value of the parallax they found:—

$$\pi = 0''.023 \pm 0''.0025.$$

Several other authors have made searches for new members of the stream. On the hypothesis that the stars of type A are moving strictly parallel to the galactic plane PLUMMER^{91, 92} has computed parallaxes for 172 A -stars with radial-velocities from CAMPBELL⁸⁵. Grouping together the stars which seem to share a common motion he

formed four large groups, for which he computed the convergent and velocity relative to the sun. The group II in his paper, which accounts for 19 stars (3 of which form part of the Taurus-cluster), has the convergent

$$A = 87^{\circ}, D = +7^{\circ}_3, \Omega = 37.9 \text{ km./sec.}$$

From the good agreement between this convergent and the convergent of BOSS the author suggests that "the Taurus stream is no mere localised cluster, but contains members, which are scattered over the whole sky". This conclusion, on the basis of an hypothesis only approximately true (of the computed parallaxes 23% are negative or excessive), seems to have but little chance of being confirmed by later investigations.

Considering the Taurus-cluster as the centre of a spiral, the branches of which are as yet unknown, HNATEK⁵⁸ has undertaken an investigation of the stars in the Grb.-Catalogue and Porters catalogue of 1340 Proper motion stars and has in the first catalogue found thirty stars between $\alpha = 0^h$ and $\alpha = 4^h$ with proper motions in the direction of the point of convergence of the Taurus-stream (or perhaps of KAPTEYN's vertex). The stars seem to lie on a branch which extends from the centre of the group in the direction of decreasing α and increasing δ . The mean distance, computed on the assumption of membership in the cluster, is the double of the distance of the cluster. Because of the limits of the catalogue used, there is a gap in the branch between $\delta = +20^{\circ}$ and $\delta = +40^{\circ}$. As no radial-velocities are known, the hypothesis still rests on a rather weak ground.

As new members of the group HERTZSPRUNG⁵³ has proposed seven stars of the later spectral-types: 41 H Andromedæ (F), δ Trianguli (G), Θ Ursæ maj. (F), 11 Leonis min. (K), Aë 10603 (K), Lal. 27742 (G), P XXIII 267 (F), which, with small deviations, move towards the convergent:—

$$A = 92^{\circ}_3, D = +7^{\circ}_1, \Omega = 44 \text{ km./sec. (1900.)}$$

The absolute radial velocity of Θ Ursæ maj. is, according to KÜSTNER, $+15 \text{ km.}$, and the computed value $+22 \text{ km.}$

Without result CURTIS⁵⁴ has made a search for faint members of the cluster in the region of T Tauri. HERTZSPRUNG⁵¹ has made a new determination of the parallax of the Taurus-cluster from the radial-velocities and the yearly change in the apparent diameter of the group, which from the proper motions he has computed to be a millionth at the present time. The stars used are the 41 stars in BOSS's memoir augmented by ι Tauri (P. G. C. 1194), and as radial-velocity for the centre of the group he applies $+38 \text{ km./sec.}$ and gets the following parallax:—

$$\pi = 0''.027 \pm 0''.002.$$

As new members he points out two double stars from Groningen Publ. 24⁷⁰, Lal. 9091 and 9109 with radial-velocities from Mt. Wilson⁶ $+38 \text{ km./sec.}$ Another possible member, the double star 55 Tauri, gives a parallax of $\pi = 0''.025$ on the assumption that the sum of the two masses is equal to that of the sun.

In a later paper HERTZSPRUNG⁵² shows, that a linear relation exists between the colour-index (or the spectral-type) and the photographic magnitudes of the stars in the cluster, with the exception of the four yellow stars P. G. C. 1000, 1017, 1044, 1045,

which have the same absolute magnitude as the white stars in the group (giants), while the other yellow stars are 6—7 magnitudes fainter (dwarfs). As has been shown by KOHLSCHÜTTER⁷³, our sun also, and perhaps the stars in Præsepe, fulfils this condition.

If the motions of the Hyades are parallel in space, the component of the proper motion at right angles to the line from the star to the convergent ought to be zero except for errors of observation. O'CONNOR³¹ has observed that these components, although very small, change signs near the position-angles 153° and 333° (arranged around the point $\alpha = 4^h 20^m$, $\delta = +14^\circ 8'$), and have their greatest numerical values 90° from these points. From this he concludes that the stars are revolving about a common centre near $\alpha = 4^h 20^m$ and $\delta = +14^\circ 8'$. He assumes a central group revolving as a solid mass, and the rest scattered in the same plane as the centre, but the outside stars moving less than the inside ones. The regularity in the residuals does not seem to be evident enough to establish the reason of his hypothesis.

With the proper motions from BOSS's Prel. General Catalogue and the radial velocities from VOÛTE¹²⁰ or from the Carte-Catalogue at the Lund Observ. (GYLLENBERG), I have made a new determination of the convergent. I have used the method of CHARLIER, but with some modification. From the slight deviations of the stars from the parallel motion, there will arise points of intersection within or in the vicinity of the group, especially from the most crowded stars, that will cause a displacement of the convergent in the direction of the cluster. In order to eliminate the influence of these small deviations I have grouped the stars in three parallel groups. For each group I have taken the mean of the coefficients a , b and c , computed for each star separately, and then formed the equations of condition. In table I n denotes the number of stars and $\bar{a}$, $\bar{b}$, $\bar{c}$ the mean values of the constants for the three groups.

TABLE I.

	I	II	III
n	19	10	10
$\bar{a}$	— 3.968	— 5.811	— 1.786
$\bar{b}$	— 1.462	— 1.556	— 1.459
$\bar{c}$	10.637	9.885	10.875

From this the convergent is computed to be:—

$$A = 93^\circ 2' \pm 1^\circ 1', \quad D = +7^\circ 0' \pm 1^\circ 1'.$$

The mean deviation in position-angle is then $\pm 2^\circ 3'$, while with BOSS's point of convergence it will be $\pm 2^\circ 5'$. The stream-velocity determined from 15 radial-velocities in the card-catalogue (same weight) is

$$\Omega = 8.7 \text{ sir./st.} = 41.2 \text{ km./sec.}$$

with a mean error of ± 0.4 sir. From 9 stars in VOÛTE (991 rejected because of abnormal radial-velocity, being only $+6.7$ km.) I get:—

$$\Omega = 42.7 \text{ km.}$$

With double weight for 1017 and 1044 (determined at two places) and half weight for 892 and 1026 (less well determined) I get:—

$$\Omega = 40.5 \text{ km./sec.}$$

(A change in the stream-velocity of 1 km. would in this case involve a change in the mean absolute magnitude of about $0^{\text{m}}_{.05}$.) In table II the distances and absolute magnitudes are computed with the velocity 8.7 sir./st.

The mean value of the parallax is

$$\pi = 0''.0275 \pm 0''.0025.$$

The mean value of the absolute magnitude for the 29 *A*-stars in the cluster and the dispersion in the absolute magnitudes are then:—

$$M_0 = 0^{\text{m}}_{.68}, \quad \sigma = \pm 0^{\text{m}}_{.67}.$$

With the assumed convergent:—

$$A = 86^{\circ}_{.5}, \quad D = +8^{\circ}_{.7},$$

KAPTEYN⁶⁶ has found:—

$$M_0 = +1^{\text{m}}_{.88}, \quad \sigma = 0^{\text{m}}_{.9}.$$

The mean absolute magnitudes of the 8 *F*-stars is

$$M_0 = +1^{\text{m}}_{.56}.$$

LUNDAHL⁸² found for the *F*-stars:—

$$M_0 = +2^{\text{m}}_{.0} \pm 1^{\text{m}}_{.75},$$

for the giants:—

$$M_0 = -0^{\text{m}}_{.81} \pm 0^{\text{m}}_{.75},$$

for the dwarfs:—

$$M_0 = +2^{\text{m}}_{.5} \pm 0^{\text{m}}_{.80}.$$

RUSSELL (Nature, vol. 93) giants (*F* 3):—

$$M_0 = 0^{\text{m}}_{.0},$$

dwarfs:—

$$M_0 = +3^{\text{m}}_{.3}.$$

Released from the motion of the sun the convergent will be:—

$$A_0 = 95^{\circ}_{.3}, \quad D_0 = 32^{\circ}_{.7}, \quad \Omega_0 = 27.8 \text{ km.}$$

or in galactic coordinates:—

$$L_0 = 148^{\circ}_{.8}, \quad B_0 = +11^{\circ}_{.1}.$$

The moments around the medium being:—

$$\begin{array}{lll} v_{11} = +0.540, & v_{22} = +0.842, & v_{33} = +0.177, \\ v_{12} = +0.000, & v_{13} = +0.059, & v_{23} = +0.002, \end{array}$$

I get the equation of third degree:—

$$t^3 - 1.059 t^2 + 0.337 t - 0.0315 = 0,$$

from which

$$\begin{aligned} t_1 &= 0.342, & t_2 &= 0.167, & t_3 &= 0.550, \\ \alpha_1 &= 0.59, & \alpha_2 &= 0.41, & \alpha_3 &= 0.74, \end{aligned}$$

which gives the density:—

$$C = 14.85,$$

TABLE II.

THE TAURUS-CLUST

P.G.C.	Star-name	Sp.	<i>m</i>	<i>α</i>	<i>δ</i>	<i>u</i>	<i>v</i>	<i>w</i>		<i>π</i>
								C. C. (sir.)	Voûte (km.)	
892	Pi. 187	<i>F</i>	5 ^m .96	56°75	+ 17°02	+ 0''143	— 0''033	+ 5.43	+ 26 B	[0''019]
919	Pi. 215	<i>F</i>	5.76	58.75	+ 17.90	+ 0.136	— 0.087			[0.019]
935	Pi. 234	<i>A</i>	5.48	59.62	+ 7.92	+ 0.159	+ 0.012	+ 6.95	+ 32.9 A	
952	Br. 562	<i>G</i>	5.67	60.33	+ 19.33	+ 0.106	— 0.043	+ 4.56	+ 21.6 B	{ 0.024 Mc
961	Br. 566	<i>F</i>	5.71	61.50	+ 5.25	+ 0.142	+ 0.013			[0.014]
980	Br. 572	<i>F</i>	6.35	62.52	+ 15.15	+ 0.122	— 0.015			[0.030]
991	Br. 576	<i>A</i> ₅	5.56	63.12	+ 21.33	+ 0.105	— 0.039	+ 1.41	+ 6.7 A	[0.018]
1000	γ Tauri	<i>G</i>	3.86	63.52	+ 15.38	+ 0.117	— 0.027	+ 8.02		[0.023]
1004	Br. 585	<i>A</i>	5.59	63.58	+ 13.78	+ 0.118	— 0.028			
1007	Br. 586	<i>A</i>	5.27	63.72	+ 14.85	+ 0.112	— 0.033			
1013	Br. 589	<i>A</i>	5.76	64.10	+ 13.33	+ 0.114	— 0.031			
1017	δ Tauri	<i>K</i>	3.93	64.30	+ 17.30	+ 0.110	— 0.033	+ 8.15	+ 37.8 L, C	[0.020]
1018	Br. 596	<i>A</i> ₂	5.63	64.43	+ 16.53	+ 0.109	— 0.032		+ 36.4 orb.	
1022	Br. 597	<i>A</i> ₂	4.84	64.58	+ 17.20	+ 0.117	— 0.041	+ 8.12		
(1025)	Abd 105	<i>F</i>	5.96	64.77	+ 18.80	+ 0.107	— 0.063			[0.016]
1026	α ₁ Tauri	<i>A</i> ₃	4.36	64.85	+ 22.08	+ 0.101	— 0.048	+ 8.44	+ 40 L	
1027	α ₂ Tauri	<i>A</i> ₂	5.42	64.87	+ 21.97	+ 0.117	— 0.060			
1029	Br. 601	<i>A</i>	4.24	64.93	+ 17.63	+ 0.107	— 0.025	+ 7.63	+ 36.4 L	
1031	Br. 603	<i>A</i>	6.39	64.98	+ 15.70	+ 0.111	— 0.029			
1033	ν Tauri	<i>A</i> ₅	4.40	65.08	+ 22.58	+ 0.112	— 0.052			
1034	Br. 605	<i>A</i>	4.60	65.15	+ 15.33	+ 0.114	— 0.027			
1040	Pi. 82	<i>A</i>	5.74	65.52	+ 21.33	+ 0.109	— 0.045			
1043	Br. 611	<i>A</i>	5.97	65.63	+ 14.52	+ 0.109	— 0.021			
1044	ε Tauri	<i>K</i>	3.63	65.70	+ 18.95	+ 0.114	— 0.033	+ 8.32	+ 38.9 L, B	[0.030]
1045	θ ₁ Tauri	<i>K</i>	4.04	65.72	+ 15.73	+ 0.104	— 0.028			[0.030]
1046	θ ₂ Tauri	<i>A</i> ₅	3.62	65.75	+ 15.63	+ 0.104	— 0.025	+ 9.82	+ 42.6 orb.	
1047	Br. 614	<i>A</i> ₅	5.12	65.80	+ 12.82	+ 0.110	— 0.018			
(1051)	Br. 617	<i>A</i>	5.70	66.10	+ 15.42	+ 0.106	— 0.012			
1054	Br. 619	<i>A</i> ₅	4.84	66.20	+ 15.97	+ 0.112	— 0.032	+ 8.44		
1055	Br. 620	<i>F</i>	5.49	66.22	+ 15.47	+ 0.106	— 0.030			[0.017]
1056	Br. 621	<i>A</i>	5.49	66.25	+ 13.50	+ 0.103	— 0.020			
1058	Br. 623	<i>F</i>	6.04	66.53	+ 15.63	+ 0.105	— 0.031			[0.020]
1067	ρ Tauri	<i>A</i> ₅	4.75	67.05	+ 14.63	+ 0.100	— 0.026			
1086	Br. 638	<i>F</i>	5.80	68.10	+ 15.32	+ 0.089	— 0.029			[0.018]
1087	Br. 639	<i>A</i> ₅	4.30	68.15	+ 12.30	+ 0.104	— 0.010			
1090	σ ₂ Tauri	<i>A</i>	4.85	68.40	+ 15.72	+ 0.082	— 0.020	+ 15.43		
1092	Pi. 146	<i>A</i>	5.55	68.43	+ 7.67	+ 0.032	— 0.001			
1114	Pi. 169	<i>A</i>	5.35	68.72	+ 10.95	+ 0.097	— 0.014			
(1122)	Pulk. 721	<i>A</i>	5.43	70.12	+ 11.52	+ 0.066	— 0.001			
1143	Br. 666	<i>A</i>	5.12	71.37	+ 18.67	+ 0.034	— 0.036	+ 5.28		
1184	Br. 694	—	—	73.50	+ 15.75	+ 0.098	— 0.034			
(1194)	ι Tauri	<i>A</i> ₅	4.70	74.27	+ 21.43	+ 0.067	— 0.047	+ 8.87	+ 42 L	
1226	Br. 716	<i>A</i>	5.42	75.95	+ 9.70	+ 0.074	— 0.006	+ 6.84	+ 32.4 A	

and the direction of the principal axes (roughly):—

$$\begin{aligned} L_1 &= 91^\circ_9, & B_1 &= 0^\circ_0, \\ L_2 &= 3^\circ_9, & B_2 &= -80^\circ_3, \\ L_3 &= 0^\circ_1, & B_3 &= 9^\circ_0. \end{aligned}$$

The cluster has an ellipsoidal form with no great difference between the axes. The distribution in space is shown in fig. II:—a)-c) in rectilinear galactic coordinates expressed in sirimeters.

$$= 93^\circ_2; D = +7^\circ_0; \Omega = 8.7 \text{ sir./st.}$$

Group	q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
I	101 ³	— 1 ⁷	36 ⁸	7.81	+ 1.64	+ 6.95	+ 1.52	0 ⁰ .028	[0 ⁰ .009]	— 5.09	+ 4.14	— 3.22
I	103.7	— 1.5	35.1	7.81	+ 1.44	+ 7.11		0.028	[0.009]	— 5.23	+ 4.14	— 3.00
III	89.8	+ 3.6	33.2	6.15	+ 2.03	+ 7.27	+ 0.32	0.084		— 4.64	+ 2.60	— 3.09
II	107.1	— 5.0	33.5	8.64	+ 0.98	+ 7.24	+ 2.68	0.024	{ 0.000 [0.010]	— 6.32	+ 4.94	— 3.20
III	85.8	+ 0.5	31.3	6.53	+ 1.63	+ 7.42		0.032	[0.002]	— 5.09	+ 2.43	— 3.29
I	101.9	+ 0.3	30.9	7.88	+ 2.01	+ 7.45		0.028	[0.015]	— 5.66	+ 3.74	— 2.92
II	111.9	+ 1.5	32.2	8.58	+ 0.90	+ 7.35	+ 5.94	0.024		— 6.36	+ 4.98	— 2.75
I	102.9	— 0.1	30.1	7.50	— 0.51	+ 7.51	— 0.51	0.028	[0.005]	— 5.80	+ 3.76	— 2.85
III	100.2	— 3.1	29.6	7.80	+ 1.27	+ 7.55		0.028		— 5.70	+ 3.51	— 2.90
I	102.1	— 4.3	29.7	7.60	+ 0.86	+ 7.54		0.027		— 5.92	+ 3.76	— 2.92
III	100.6	— 4.7	29.2	7.40	+ 1.41	+ 7.58		0.028		— 5.82	+ 3.54	— 2.89
I	106.6	— 0.1	29.8	7.76	— 0.52	+ 7.53	— 0.62	0.027	[0.007]	— 6.01	+ 4.07	— 2.73
I	105.4	— 1.0	29.5	7.77	+ 1.23	+ 7.56		0.027		— 6.06	+ 3.98	— 2.79
I	106.7	— 2.6	29.6	7.14	+ 0.57	+ 7.55	— 0.63	0.029		— 5.56	+ 3.72	— 2.50
	120.5	+ 11.0	29.9	7.20	+ 1.67	+ 7.53		0.029	[0.013]	— 5.56	+ 3.90	— 2.38
II	114.7	— 0.7	31.0	8.25	— 0.23	+ 7.45	— 0.99	0.025		— 6.25	+ 4.81	— 2.43
II	114.7	— 2.4	30.9	7.00	+ 1.19	+ 7.45		0.030		— 5.31	+ 4.06	— 2.07
II	107.8	+ 4.7	29.4	8.00	— 0.28	+ 7.57	— 0.23	0.026		— 6.24	+ 4.20	— 2.73
I	104.7	— 0.2	28.8	7.52	+ 2.01	+ 7.61		0.027		— 5.93	+ 3.75	— 2.71
II	115.8	+ 0.9	31.1	7.50	+ 0.02	+ 7.44		0.028		— 5.67	+ 4.40	— 2.15
I	103.9	+ 0.6	28.6	7.32	+ 0.27	+ 7.63		0.028		— 5.80	+ 3.61	— 2.65
II	114.4	+ 2.0	30.2	7.64	+ 1.32	+ 7.51		0.027		— 5.37	+ 4.35	— 2.25
I	102.7	+ 1.8	27.9	7.55	+ 1.58	+ 7.63		0.027		— 6.04	+ 3.61	— 2.75
II	110.6	+ 2.2	29.2	7.28	— 0.63	+ 7.58	— 0.74	0.028	[0.002]	— 5.69	+ 3.91	— 2.32
I	105.0	— 0.1	28.2	7.86	— 0.44	+ 7.65		0.026	[0.004]	— 6.25	+ 3.88	— 2.76
I	104.8	+ 1.3	28.1	7.89	— 0.86	+ 7.66	— 2.26	0.026		— 6.28	+ 3.88	— 2.78
III	99.6	+ 0.3	27.4	7.40	+ 0.77	+ 7.71		0.028		— 5.97	+ 3.35	— 2.81
	104.7	+ 8.2	27.7	7.80	+ 1.24	+ 7.69		0.026		— 6.24	+ 3.72	— 2.73
I	105.8	— 0.1	27.7	7.16	+ 0.57	+ 7.69		0.029		— 5.72	+ 3.54	— 2.46
I	104.9	— 0.9	27.5	7.50	+ 1.11	+ 7.70	— 0.75	0.028	[0.011]	— 6.01	+ 3.66	— 2.61
III	101.1	+ 0.6	27.1	7.43	+ 1.13	+ 7.73		0.028		— 6.01	+ 3.42	— 2.73
I	105.4	— 1.0	27.3	7.50	+ 1.66	+ 7.72		0.028	[0.008]	— 6.03	+ 3.66	— 2.57
I	103.9	— 0.7	26.7	7.79	+ 0.29	+ 7.76		0.027		— 6.33	+ 3.66	— 2.70
I	108.0	— 1.0	25.9	8.86	+ 1.19	+ 7.81		0.025	[0.007]	— 6.88	+ 4.01	— 2.68
III	99.9	+ 4.4	25.1	7.27	— 0.01	+ 7.87		0.028		— 6.04	+ 3.13	— 2.58
I	107.1	+ 3.4	25.6	9.17	+ 0.03	+ 7.33	(— 7.60)	0.023		— 7.52	+ 4.37	— 2.92
III	90.0	— 0.7	24.4	9.03	+ 0.77	+ 7.91		0.023		— 7.62	+ 3.26	— 3.57
III	97.8	— 0.4	23.3	7.23	+ 1.05	+ 7.98		0.029		— 6.13	+ 2.89	— 2.51
	99.3	+ 8.4	23.0	10.57	+ 0.81	+ 8.00		0.020		— 8.98	+ 4.29	— 3.56
II	116.3	+ 3.1	24.0	9.97	+ 0.61	+ 7.98	+ 2.65	0.026		— 6.63	+ 3.95	— 2.00
II	112.4	+ 3.3	21.0	6.49	—	+ 8.11		0.032		— 5.33	+ 2.73	— 1.56
	125.9	+ 0.9	23.2	8.63	+ 0.02	+ 7.98	— 0.89	0.024		— 7.25	+ 4.42	— 1.68
III	97.8	+ 3.2	17.0	7.06	+ 1.17	+ 8.31	+ 1.47	0.029		— 6.36	+ 2.38	— 1.95

CHAPTER III.

THE URSA MAJOR-CLUSTER.

Here, too, PROCTOR⁹⁸ suggested first that a connected system was formed by the five stars β , γ , δ , ϵ , ζ Ursæ majoris, whose proper motions are almost parallel.

With proper motions from MÄDLER and radial-velocities from HUGGINS, KLINKERFUES⁷¹ determined the convergent:—

$$A = 218^{\circ}53', \quad D = +44^{\circ}25',$$

and the mean parallax:—

$$\pi = 0''.026.$$

With proper motions from AUWERS-BRADLEY and radial-velocities from Potsdam for four stars HÖFFLER⁵⁹ repeated the calculation with equations of the form:—

$$\begin{aligned} \mu_i &= x \cos s_i + y \sin s_i, \\ x &= \pi \Omega \sin \lambda, \quad y = \pi \Omega \cos \lambda, \end{aligned}$$

where s_i is the angle between a star and ζ Ursæ maj., and got:—

$$\begin{aligned} A &= 303^{\circ}7, \quad D = -34^{\circ}9, \quad \Omega = 9.642 \text{ sir./st.}, \\ \pi &= 0''.0165 \pm 0''.0111. \end{aligned}$$

Admitting the uncertainty in the convergent, resting only on the deviation of the proper motion of β Ursæ maj. from the others, KOBOLD⁷² computed:—

$$A = 318^{\circ}7, \quad D = -56^{\circ}0.$$

Later investigations of the radial-velocities by LUDENDORFF⁸⁰ showed that β , ζ and ϵ Ursæ maj. are spectroscopic binaries with variable radial-velocities (earlier suggested by ADAMS and FROST). With proper motions from Neuen Fundamentalkatalog des Berl. Astr. Jahrbuchs and carefully determined radial-velocities of β Ursæ maj. (— 16.8 km.) and ζ Ursæ maj. (— 12.6 km.), he gets the following results:—

$$\begin{aligned} A &= 303^{\circ}2 \pm 3^{\circ}0, \quad D = -36^{\circ}6 \pm 3^{\circ}5, \quad \Omega = 20.7 \text{ km./sec.} = 4.86 \text{ sir./st.}, \\ \pi &= 0''.0352. \end{aligned}$$

The variable radial-velocity of β Ursæ maj. is doubted nevertheless by CAMPBELL²⁷.

The search for stars belonging to this group has led HERTZSPRUNG⁵⁸ to the remarkable discovery of the extension of the Ursa major system over the whole sky. Among the 8 new members he found in the New Fundam. Cat. of the Berl. Astr. Jahrb. and in KAPTEYN's discussion of 2618 Bradley stars, the most remarkable is Sirius,

because of its well known radial-velocity and parallax, by which the radial-velocities of the other stars may be checked. The other new members were β Eridani, β Aurigæ, 37 Ursæ maj., δ Leonis, α Coronæ and the doubtful stars 78 Ursæ maj. and Groombr. 1930. Omitting β Eridani he computed from ten stars the point of convergence, "the point on that great circle defined by the proper motion of Sirius, which yielded the smallest sum of the squares of the geometrical deviations of the remaining proper motions" and got:—

$$A = 307^{\circ}.8, \quad D = -40^{\circ}.2 \quad (1900).$$

From the radial-velocities of the four stars α Can. maj., β and ζ Ursæ maj. and α Coronæ he then calculated the stream-velocity:—

$$\Omega = 18.4 \text{ km./sec.}$$

The radial-velocity computed for β Aurigæ by HERTZSPRUNG (—16.6) shows great deviation from the radial-velocity observed by VOGEL (—20.2) and LUDENDORFF (—19.8) for the same star. A new determination of the convergent was then made by LUDENDORFF⁸¹ with equations of the form:—

$$\cot q_i = \frac{\cos \delta_i \sin D - \sin \delta_i \cos D \cos(A - \alpha_i)}{\cos D \sin(A - \alpha_i)}.$$

From an approximate value of the convergent he gets the position-angles q_i° , and from the differences $q_i - q_i^{\circ}$ he computes a corrected value of the convergent. With the same ten stars as HERTZSPRUNG he found:—

$$A = 309^{\circ}.2, \quad D = -41^{\circ}.7,$$

and omitting β Aurigæ and α Coronæ:—

$$A = 309^{\circ}.3, \quad D = -42^{\circ}.2.$$

From the radial-velocity of Sirius (—8.1, mean value from EBERHARD-MÜNCH, LICK and ADAMS), β and ζ Ursa maj. (—16.8, —12.6), β Aurigæ (—19.8), α Coronæ (+0.4, mean value from JORDAN and CANNON), he computed the stream-velocity:—

$$\Omega = 19.8 \text{ km./sec.,}$$

and from the three stars first mentioned:—

$$\Omega = 18.6 \text{ km./sec.}$$

By a simple transformation of the rectangular coordinates in space, given by HERTZSPRUNG, TURNER¹¹⁸ has demonstrated the flatness of the Ursa major-cluster. When the residuals for the ξ and η coordinates have mean numerical values of about —17.0 and —8.0, the residuals of the ζ coordinate have a mean of only —2.0. The effect is diminished considerably when the suspected stars β Eridani, β Aurigæ and Groombr. 1930 are omitted. The mean values of the residuals are then reduced to —7, —8, —2. The plane of the

Ursa major-cluster is nearly perpendicular to the galactic plane, and the movements are approximately in this plane.

By BOTTlinger²⁰ the group has been further revised. The stars for which the quotient $\frac{\mu \sin \mathcal{A}q}{m.e} \leq 3$ (where *m.e* is the mean error in the proper motion) are considered as belonging to the group, the others excluded. The cluster then has been increased by the stars Boss 553, ξ Eridani, γ Ursæ maj., 78 Virginis, β Serpentis, 76 Cygni and less probable members Boss 417 and 5425, α Volantis, 41 Virginis, while β Eridani and Groombr. 1930 are excluded. The convergent, for which the sum of the squares of $\mu \sin \mathcal{A}q$ is a minimum, is:—

$$A = 307^{\circ}.9, \quad D = -40^{\circ}.0, \quad \Omega = 18.4 \text{ km./sec.}$$

The mean of the absolute magnitudes of 20 *A*-stars he found to be:—

$$M_0 = +0^m_{21}.$$

BOTTlinger points out that the values of $\mu \sin \mathcal{A}q$ are positive for the Ursa major stars (except ϵ Ursæ maj.) and negative for the stars scattered in the sky (except ξ Bootis, for which the value is = 0). He then supposes a rotation to the right ("Rechtsschraube") of the Ursa major stars and a rotation to the left ("Linksschraube") of the others. The great part of the doubtful stars shows a rotation of the first direction. The Ursa major system then shows us a cluster flattened in the direction of its own motion, in which two streams are rotating in opposite directions.

In a short memoir of GUTHNICK and PRAGER⁴⁷ it is suggested that the plane of the Ursa major system is parallel to the plane of the eclipsing variables in the group, which seems to be in conformity with the investigations of the orbits of the spectr. binaries β and ϵ Ursæ majoris, β Aurigæ and α Coronæ, and seems also to be verified by the visual double star Sirius.

New members are suggested by PLUMMER⁹⁷, with parallaxes computed from the hypothesis:—motion parallel to the galactic plane:—37 Ursæ maj. ($\pi = 0''.045$), Groombr. 1930 ($0''.028$), 18 Ursæ maj. ($0''.042$), P. G. C. 411 ($0''.048$), 1420 ($0''.161$), 1768 ($0''.135$), 2999 ($0''.056$). The first two are mentioned earlier.

The position of the Ursa major system in space has been investigated by COURVOISIER³³. He uses galactic coordinates, referred to the points $\alpha = 191^{\circ}$, $\delta = +28^{\circ}$ as galactic pole, and $\alpha = 309^{\circ}$, $\delta = +42^{\circ}$ as zero-point for galactic longitude, and the coordinates expressed in "Sternweite" (parsecs) ($\pi = 1''$). He found that the stars in BOTTlinger's memoir are uniformly distributed around a plane parallel to the Milky Way, with a distance of about 13 parsecs from this plane. The stars are arranged in two parallel strings ("Schnüre") with a mutual distance of 18 parsecs and an inclination to the galactic plane of about 56° . (Compare Fig. III.) The direction of their projection on the Milky Way coincides well with the absolute direction of the star-stream. The first string is rather short and embraces the eight stars in Ursa major; the second is very long and adopts nine stars, among which Sirius, but also the stars rejected by BOTTlinger β Eridani, 45 Bootis and δ Leonis. For the determination of the curvature in the orbit of the stream the author assumes in the first approximation the absolute motion strictly parallel to the galactic plane. *K* denoting the supplement-angle between two tangents to the orbit, for which the points of tangency have a mutual distance of 1 parsec, *k* is computed by putting the deviations in longitude for the absolute motions of the stars proportional to

the distances of the stars from the centre of the group. With corrected values of the constants of precession he finally gets:—

$$K = 0^{\circ}0618 \pm 0^{\circ}0156,$$

by which the sum of the squares of the deviations in the position-angles is reduced to $1/11$. The radius of the curvature then is 927 ± 234 parsecs, and if the orbit is circular, the period of revolution will be about 180 million years. From the mean of three hypotheses concerning the form of the orbit (circle through the galactic centre, Arkimedes' spiral and logarithmic spiral) he computed the distance from the centre of the Milky Way to the centre of the Ursa major system to be about 1100 parsecs. The ordinary form of the spiral nebula observed by V. D. PAHLEN⁸⁹ is a logarithmic spiral; but the curvature in the Ursa major system seems to be variable, which suggests an Arkimedes' spiral in this special case.

The dilated system of Ursa major is the object of a critical examination by DZIEWULSKI⁸⁹. Denoting by ω the area of a segment, the radius of which is the greatest distance of the convergency-point from any stars' proper motion circle, he computes the quotient $\frac{n}{N} : \frac{\omega}{4\pi}$, where n is the number of the stars in the group and N the whole star numbers in the catalogue (6188). For the 17 stars in the first group by BOTTLINGER this quotient is 2.05, with 14 stars (BOSS 553, 78 Virginis and β Serpentis rejected) the quotient will be 5.4, and for the eight stars with known parallaxes (β Aurigæ, α Canis maj., α Coronæ and the five Ursa-stars) the ratio is 10.3. But from the distance of the absolute convergent from KAPTEYN's vertex and with KAPTEYN's distribution of the proper motions, we are obliged to expect the number of stars moving in this direction to be 1.78 times larger than if the stars' proper motions were distributed at random, which diminishes the quotients to 1.1, 3.0 and 5.7. The hypothesis of a dilated Ursa major system, then, is entitled only when it is limited to members whose proper motion-circles pass within a small area around the convergent.

With the method II I have calculated for the Ursa major-cluster from the p. m. of the 17 BOTTLINGER's stars the convergent:—

$$A = 307^{\circ}6 \pm 3^{\circ}0, \quad D = -39^{\circ}9 \pm 1^{\circ}7.$$

The equations of condition are:—

$$\begin{cases} 13.740x - 0.803y + 10.798 = 0, \\ -0.803x + 3.259y - 3.686 = 0. \end{cases}$$

From the parallax of Sirius:— $\pi = 0''.38$, I get the stream-velocity:—

$$\Omega = 3.92 \pm 0.31 \text{ sir./st.}$$

In table III the stars bracketed are the doubtful stars in the table of BOTTLINGER. Great deviations in parallax or radial-velocity are shown especially by 78 Ursæ maj. and ξ Bootis, both of the later spectral-type. The absolute magnitudes are abnormally small for the A -stars 80 Piscium and 45 Bootis. From the 15 A -stars not bracketed I get the mean absolute magnitude:—

$$M_0 = -0^m_{58}, \quad \sigma = \pm 0^m_{90}.$$

For all A -stars:—

$$M_0 = -0^m_{68}.$$

The convergent reduced from the solar motion:—

$$A_0 = 286.3, \quad D_0 = -3.65, \quad \Omega_0 = 30 \text{ km./sec.}, \\ L_0 = 0.0, \quad B_0 = -7.6.$$

From the 17 stars I get the moments around the medium:—

$$\nu_{11} = 15.602, \quad \nu_{22} = 12.453, \quad \nu_{33} = 23.894, \\ \nu_{12} = 0.813, \quad \nu_{13} = 8.989, \quad \nu_{23} = -8.891,$$

and the equation:—

$$t^3 - 51.95 t^2 + 104.12 t - 2258.06 = 0,$$

which has the roots:—

$$t_1 = 14.93, \quad t_2 = 32.35, \quad t_3 = 4.68.$$

The dispersion along the three principal axes are then:—

$$\alpha_1 = 3.86, \quad \alpha_2 = 5.69, \quad \alpha_3 = 2.16,$$

and the direction of these axes:—

$$L_1 = 220.7, \quad L_2 = 320.6, \quad L_3 = 306.3, \\ B_1 = +6.5, \quad B_2 = +56.1, \quad B_3 = -33.0.$$

TABLE III.

THE URSA MAJOR-CLUSTER

P.G.C.	Star-name	Sp.	<i>m</i>	<i>α</i>	<i>δ</i>	<i>u</i>	<i>v</i>	<i>w</i>		<i>π</i>	<i>ρ</i>
								C. C. (sir.)	Voûte (km.)		
(252)	80 Piscium . . .	<i>A</i>	5.67	15° 80	+ 5° 12	— 0° 272	— 0° 181		+ 6.6 W	[0° 028]	236
417		<i>A</i>	6.05	26.77	— 50.70	— 0.051	— 0.011				257
553		<i>A</i>	5.84	35.32	— 15.78	— 0.056	— 0.051				227
1024	ξ Eridani	<i>A₂</i>	5.23	64.55	— 3.98	— 0.049	— 0.052	— 0.06	— 0.3 W	0.010 Mc	222
(1220)	β "	<i>A₂</i>	2.92	75.93	— 5.22	— 0.088	— 0.079		— 8 L	0.022 F	223
1478	β Aurigæ	<i>A_p</i>	2.07	88.05	+ 44.93	— 0.047	— 0.005	— 3.82	— 19 orb.	0.028 G, F, Mc	263
1732	α Can. maj. . . .	<i>A</i>	— 1.58	100.18	— 16.58	— 0.526	— 1.206	— 1.56	— 8 orb.	0.876 G	203
2440	α Volantis . . .	<i>A₃</i>	4.18	135.22	— 66.00	— 0.014	— 0.102		+ 6 L	0.867 Lu	187
2813	37 Ursæ maj. . .	<i>F</i>	5.16	157.18	+ 57.60	+ 0.067	+ 0.081	— 2.81	— 11.2 L, W	[0.029]	63
2930	β " "	<i>A</i>	2.44	163.95	+ 56.92	+ 0.084	+ 0.028	— 2.53	— 10.9 orb.	0.074 F, Lu	71
(2972)	δ Leonis	<i>A₂</i>	2.58	167.20	+ 21.07	+ 0.149	— 0.145	— 3.80	— 18 L		134
3117	γ Ursæ maj. . .	<i>A</i>	2.54	177.13	+ 54.25	+ 0.094	+ 0.003	— 1.90	— 10.0 L, W	0.047 F, Lu	89
3190	δ " "	<i>A₂</i>	3.44	182.62	+ 57.58	+ 0.109	+ 0.003	— 2.82	— 10.7 L, W		88
3360	41 Virginis . . .	<i>A</i>	6.34	192.20	+ 12.97	+ 0.059	— 0.033		— 3.8 W		113
3363	ε Ursæ maj. . .	<i>A</i>	1.68	192.40	+ 56.50	+ 0.115	— 0.011	— 1.90	— 11.9 orb.	0.047 F, Lu	93
3382	78 " "	<i>F</i>	4.89	194.10	+ 56.90	+ 0.093	— 0.023	— 1.48	— 5.0 L, W	0.026 All	103
3474	ζ ₁ " "	<i>A_p</i>	2.40	199.97	+ 55.45	+ 0.126	— 0.030	— 1.78	— 9.6 orb.	0.087 G, F, Lu	103
3475	ζ ₂ " "	<i>A₂</i>	3.96	199.97	+ 55.45	+ 0.132	— 0.035			0.046 Mc	104
3480	g " "	<i>A₃</i>	4.02	200.30	+ 55.52	+ 0.121	— 0.024	— 2.58	— 12 L	0.017 Mc	107
3506	78 Virginis . . .	<i>A_p</i>	4.93	202.27	+ 4.17	+ 0.042	— 0.031	— 1.27	— 7 L, W	0.029 Mc	120
(3752)	ζ Bootis	<i>A₂</i>	4.33 } 4.43 }	219.10	+ 14.15	+ 0.055	— 0.027		— 6 L		110
3798	ξ " "	<i>K_{sp}</i>	4.64	221.70	+ 19.52	+ 0.130	— 0.106	+ 0.93	+ 4.4 L	[0.131] 0.178 All, Mc	129
(3855)	45 " "	<i>A₃</i>	5.03	225.73	+ 25.27	+ 0.187	— 0.183	— 1.48	— 7 L	[0.046] 0.059 All	134
3961	α Coronæ	<i>A</i>	2.31	232.62	+ 27.05	+ 0.120	— 0.102		+ 0.4 orb.	0.056 F, Mc	130
4009	β Serpentis . . .	<i>A₂</i>	3.74	235.40	+ 15.73	+ 0.071	— 0.057		+ 22.0 W	0.029 Mc	127
5425		<i>A</i>	6.33	315.03	+ 41.23	+ 0.002	— 0.051				177
5573	76 Cygni	<i>A</i>	6.05	324.38	+ 40.35	— 0.010	— 0.051			0.005 Mc	197
(6084)	λ Piscium	<i>A₃</i>	4.61	354.23	+ 1.23	— 0.133	— 0.144				227

The density is:—

$$C = 0.0227,$$

and the frequency-function:—

$$F = 0.0227 \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{14.83} + \frac{y_1^2}{82.35} + \frac{z_1^2}{4.98} \right)}.$$

From the 28 stars the result will be:—

$$\begin{aligned} v_{11} &= 15.752, & v_{22} &= 17.302, & v_{33} &= 29.821, \\ v_{12} &= 4.862, & v_{13} &= 9.145, & v_{23} &= -4.598, \\ t^3 - 62.88 t^2 + 1129.83 t - 5325.53 &= 0, \\ t_1 &= 34.841, & t_2 &= 20.637, & t_3 &= 7.404, \\ \alpha_1 &= 5.90, & \alpha_2 &= 4.54, & \alpha_3 &= 2.72, \\ L_1 &= 319^\circ.2, & L_2 &= 239^\circ.1, & L_3 &= 323^\circ.1, \\ B_1 &= +73^\circ.4, & B_2 &= +4^\circ.7, & B_3 &= -24^\circ.8, \end{aligned}$$

$$F = 0.0244 \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{34.84} + \frac{y_1^2}{20.64} + \frac{z_1^2}{7.40} \right)}.$$

The stream-motion, then, is approximately in the direction of the shortest of the axes.

$$= 307^\circ.6; D = -39^\circ.9; \Omega = 3.92 \text{ sir./st.}$$

q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
27.0	-9.3	283.0	2.41	+3.76	+0.88		0.086	[0.063]	-0.24	+1.81	-2.01
48.9	-8.9	306.8	12.54	+0.55	+2.32		0.016		-2.29	-5.00	-11.27
31.5	+3.8	281.7	10.56	+0.72	+0.80		0.020		-4.85	+1.78	-9.46
25.8	+2.6	252.4	10.71	-0.42	-1.19	+1.13	0.019	0.009	-8.70	+2.25	-5.82
21.4	-6.7	245.4	6.23	-1.06	-1.63		0.033	0.011	-5.66	+0.69	-2.50
65.8	+2.0	209.3	8.42	-2.56	-3.42	-0.40	0.025	0.003	-5.83	+5.83	+1.70
03.5	-0.1	242.0	0.54	-0.26	-1.84	+0.28	0.380	0.004	-0.52	-0.14	-0.07
73.9	-13.7	286.2	7.54	-0.21	+1.09		0.027		-2.50	-6.91	-1.67
60.0	-5.2	206.0	4.79	+1.76	-3.53	+0.72	0.043	[0.014]	-1.39	+2.56	+3.80
69.8	-1.8	209.0	4.46	-0.81	-3.43	+0.90	0.046	0.088	-1.06	+2.27	+3.69
28.3	-5.9	218.6	2.43	+0.65	-3.07	-0.73	0.085		-0.88	-0.21	+2.26
87.1	-1.1	215.8	5.04	-0.97	-3.18	+1.28	0.041	0.006	-0.66	+2.26	+4.45
87.6	-0.7	219.0	4.63	+0.11	-3.05	+0.72	0.045		-0.82	+2.29	+4.01
28.5	+9.3	242.3	10.69	+1.19	-1.82		0.019		+0.40	-2.77	+10.32
96.7	+1.2	224.4	4.92	-1.78	-2.80	+0.90	0.042	0.005	+0.11	+2.35	+4.32
97.6	-5.6	225.2	5.68	+1.12	-2.76	+1.28	0.036	0.010	+0.22	+2.75	+4.97
03.3	-0.1	228.7	4.68	-0.95	-2.59	+0.81	0.044	0.002	+0.46	+2.18	+4.12
03.5	-1.3	228.7	4.47	+0.71	-2.59		0.046	0.029	+0.44	+2.08	+3.93
03.5	+2.3	228.9	4.92	+0.56	-2.58	+0.05	0.042	0.013	+0.50	+2.29	+4.32
30.2	+3.8	255.6	15.07	-0.96	-0.98	-0.29	0.014		+3.19	-5.93	+13.48
29.3	+13.2	262.1	12.93	$\begin{cases} -0.73 \\ -1.13 \end{cases}$	-0.54		0.016		+6.10	-2.35	+11.16
29.2	+0.0	260.7	4.75	+1.25	-0.63	+1.56	0.043	0.135	+2.35	-0.39	+4.11
29.5	-4.9	259.9	3.04	+2.61	-0.69	-0.79	0.068	0.009	+1.61	+0.10	+2.58
31.8	+1.4	263.4	5.09	-1.23	-0.45		0.041	0.015	+3.07	+0.48	+4.03
33.0	+4.3	273.0	8.87	-1.00	+0.21		0.023	0.006	+6.08	-0.69	+6.42
35.8	+8.1	278.6	15.69	+0.85	+0.53		0.013		+9.66	+12.30	-1.13
92.7	+1.1	278.3	15.89	+0.11	+0.57		0.013	0.008	+8.38	+12.65	-2.56
20.5	-3.2	300.9	3.49	+1.90	+2.01		0.059		+0.95	+1.64	-2.93

CHAPTER III.

PRÆSEPE.

The photographic magnitudes of the brighter Præsepe-stars were determined by SCHWARZSCHILD¹¹¹ (1900) and WILKENS¹²³ (1906). The photographic magnitudes of the fainter stars were determined later on by HERTZSPRUNG⁵⁴ down to the 16th or 17th magnitude. The radial-velocities of 6 stars in Præsepe (5 *A*-stars, 38, 40, 41, 42 Cancrī and 88 Hall, and 1 *K*-star, 39 Cancrī) have been measured by MÜNCH and JANTZEN. The mean value is about 36 km./sec. From Boss Prel. Gen. Cat. the mean position-angle is 255°. SCHWARZSCHILD¹⁰⁸ then suggests a motion of the group parallel to that of the Taurus-cluster. On this assumption he derives a parallax for Præsepe of $\pi = 0''.0063$, when the parallax of the Hyades is $0''.025$. This is in good agreement with the magnitudes apparent, the Præsepe-stars being in mean about 2 magnitudes fainter than the stars in the Hyades of the same spectral-type. The agreement in the radial-velocities is also very good, but the calculated position-angle diverges by 15° from the observed.

Another convergent has been suggested by B. BOSS¹², namely: $A = 4^h 45^m$, $D = -15^\circ$. This point he considers as a common point of convergency for four clusters, namely Præsepe, the Pleiades, a cluster of 10 stars (4 of spectral-type *A* and 4 *B*-stars) with the mean $\alpha = 8^h 28^m$ and $\delta = -46^\circ 52'$ and a group of 6 stars scattered between the limits $\alpha = 9^h 37^m$ to $17^h 8^m$, $\delta = -75^\circ$ to $\delta = -86^\circ$. The deviations in position-angles are rather small, but in the last two groups only one radial-velocity in each group is known.

The proper-motions of the stars in Præsepe have been investigated later by VAN RHIJN¹⁰¹ and the spectral-types determined by KOHLSCHÜTTER. The latter shows that only for the stars brighter than 9^m does there exist a common motion. As physical members he finally adopts 24 stars, among which 13 have the spectral-type *A*. With the exception of four stars of the latter spectral-types (giants) there exists also in Præsepe a linear relation between the magnitude and the spectral-type. Assuming the same linear connection as in the Taurus-cluster, he gets from the difference in magnitude 2^m₅₁ and from the parallax $\pi = 0''.023$ for the Hyades a parallax of

$$\pi = 0''.0072$$

for Præsepe; while the parallax computed under assumption of a common motion for the two groups is $\pi = 0''.0058$. The hypothesis of SCHWARZSCHILD then seems to be confirmed, but the rather great difference in the position-angles remains.

From the catalogues of VAN RHIJN and SCHWARZSCHILD the parallax of Præsepe has been determined by V. SCHOUTEN¹⁰⁹ by means of a method given by KAPTEYN from the apparent magnitude and the luminosity-curve. He gets the value:—

$$\pi = 0''.024.$$

Assuming the mean absolute magnitude M_0 to be firstly $+0^m_5$ and secondly -0^m_2 , I have calculated a convergent to the five brightest A -stars in the Præsepe-cluster, with the mean proper motion $\bar{\mu} = 0''.040$ and the mean apparent magnitude $\bar{m} = +6^m_5$. The equations for determining the convergent, (2) and (3), are the following:—

$$\begin{aligned} 2.233 \alpha + 0.250 \beta + 3.277 \gamma &= 0 \\ \Omega (-0.587 \alpha + 0.733 \beta + 0.344 \gamma) &= 7.6, \\ \alpha^2 + \beta^2 + \gamma^2 &= 1. \end{aligned}$$

The stream-velocity Ω is computed from the mean radial-velocity $w = 36$ km./sec. $= 7.6$ sir./st. by means of the equations:—

$$\begin{aligned} \Omega \cos \lambda &= 7.6, \\ \Omega \sin \lambda &= 4.848 \cdot \mu \cdot r, \end{aligned}$$

where r is computed from the equation:—

$$M_0 = \bar{m} - 5 \log r.$$

The result is:—

$$\begin{aligned} M_0 &= +0^m_5, \quad r = 16 \text{ sir.}, \quad \Omega = 8.21 \text{ sir./st.}, \quad A = 109^\circ_6, \quad D = +9^\circ_0, \\ M_0 &= -0^m_2, \quad r = 22 \text{ sir.}, \quad \Omega = 8.72 \text{ sir./st.}, \quad A = 103^\circ_0, \quad D = +4^\circ_5. \end{aligned}$$

The mean absolute convergent then is:—

$$\begin{aligned} A_0 &= 118^\circ, \quad D_0 = +31^\circ, \quad \Omega_0 = 28 \text{ km.}, \\ L_0 &= 158^\circ, \quad B_0 = +28^\circ. \end{aligned}$$

Several stars in the environs of Præsepe seem to share in the common motion of the group and are therefore brought together with the Præsepe stars in table IV and in fig. IV.

TABLE IV.

PRÆSEPE.

$A = 106^\circ_3$; $D = 6^\circ_8$; $\Omega = 8^\circ_5$ sir./st.

P.G.C.	Sp.	m	α	δ	u	v	π	q_0	q_c	Δq	λ	r	M
2282	G	6.55	127°40	+ 19°98	— 0.041	— 0.018	[0.011]	66°3	59°2	— 7°1	24°6	16.5	+ 0.46
2300	A_2	8.80	128.83	+ 20.06	— 0.024	— 0.019		51.6	60.2	+ 8.6	25.4	24.2	+ 1.88
2305	F'_0	6.96	128.50	+ 20.12	— 0.032	— 0.016		63.4	60.4	— 3.0	25.6	21.0	+ 0.35
2308	A	6.48	128.58	+ 20.35	— 0.038	— 0.022		59.9	60.0	+ 0.1	25.8	17.3	+ 0.29
2309	A_{5p}	6.48	128.60	+ 20.32	— 0.032	— 0.017		62.0	60.2	— 1.8	25.7	21.1	— 0.14
2310	A_{5p}	6.40	128.65	+ 20.02	— 0.035	— 0.022		57.9	60.3	+ 2.4	25.7	18.5	+ 0.06
2311	A_2	6.32	128.68	+ 19.88	— 0.031	— 0.018		59.9	61.0	+ 1.1	25.7	21.1	— 0.30
2314	A_8	6.76	128.80	+ 19.93	— 0.038	— 0.016		67.2	61.1	— 6.1	25.7	18.5	+ 0.41
(2480)	K	5.57	137.43	+ 15.35	— 0.036	— 0.018	0.015G.	63.4	76.9	+ 13.5	31.8	23.1	— 1.25
(2576)	A	6.21	142.60	+ 14.82	— 0.039	— 0.014		70.8	80.5	+ 10.2	36.6	24.8	— 0.76
(2618)	G_p	3.12	145.05	+ 24.24	— 0.041	— 0.024	[0.016]	59.6	70.7	+ 11.1	41.3	24.6	— 3.88
(2634)	A	6.01	146.05	+ 21.64	— 0.043	— 0.023		61.9	74.2	+ 12.3	41.4	23.7	— 0.86

CHAPTER V.

THE PLEIADES.

(Fig. V.)

The first determinations of the star places in the Pleiades were performed by BESSEL with the Königsberg-heliometer (1829-1841) for 52 stars relative to Alcyone. Later similar star lists have been made by ELKIN (Yale-heliometer 1885) and several others.

The proper motions of the Pleiades were investigated in 1884 by PRITCHARD⁸⁹, who proposed the hypothesis of an elliptical motion of the individual stars around the centre of the gravity of the system. This hypothesis was later on taken into consideration by HARTMAN⁴⁹, by means of the radial-velocities determined by ADAMS¹ and JUNG⁶², but was not confirmed. The group cannot, by a straight line through the centre of gravity, be divided into two groups with radial-velocities of different signs. From the difference of 11° between the position-angle of the parallactic motion and that of the group's own motion HARTMAN calculated the real part of the motion, from which he got a parallax between the limits $\pi = 0''.011$ and $\pi = 0''.016$. The proper motion and parallax of the Pleiades, especially of the 10 stars already observed by ELKIN⁴³, have been examined also by HAYN⁵⁰, who assumes the proper motion to be wholly parallactic. From the mean proper motion $0''.053$ and the distance of Alcyone from the antapex 68° he computes the parallax:—

$$\pi = 0''.013.$$

Assuming the motion strictly parallel to the galactic plane PLUMMER⁹⁶ found, when he calculated with the individual motions of the stars, the mean parallax:—

$$\pi = 0''.033,$$

and with the mean motion of the group:—

$$\pi = 0''.024.$$

He determined the convergent:—

$$A = 79.0, \quad D = -33.4, \quad \Omega = 12.0 \text{ km./sec.}$$

and the mean absolute magnitude for the *B*5-stars $M_0 = +0.3$ and for the *B*8-stars $M_0 = +0.0$.

KAPTEYN⁶³ found, under the same assumption for the six brightest stars, from proper motions and radial-velocities:—

$$\pi = 0''.018.$$

He also points out⁶⁵ that the stars from the 7th to the 9th magnitude are *A*-stars ($M_0 = +1.25$) and that the still fainter stars are of spectral-type *F*. His proper motions

are taken from catalogues of BOSS, LAGRULA, ELKIN and STRATTON. In Mount Wilson Contribution 82 KAPTEYN shows a method by means of which the parallax of stellar-clusters can be ascertained from the apparent magnitudes if the luminosity-curve is known. With the luminosity-curve given by KAPTEYN in Groningen Publ. 11 for stars $< 6^m$ and from different catalogues V. SCHOUTEN¹⁰⁸ has calculated the parallax of the Pleiades with the following results:—

Catalogue of	WOLF ¹²⁵ , MÜLLER and KEMPF ⁸⁸	$\pi = 0''.049$,
»	» CHARLIER ³⁰	$\pi = 0''.021$,
»	» GAULTIER ⁴⁵	$\pi = 0''.080$,
»	» LAGRULA ⁷⁷	$\pi = 0''.043$,
»	» HNATEK ⁵⁷	$\pi = 0''.037$,

from which he gets the mean value

$$\pi = 0''.036 \pm 0''.010.$$

Counting the stars in the catalogue of DUGAN⁸⁶ and SCHILLER¹⁰⁷ for fainter stars (12^m - 14^m) he found no members of the cluster, which does not seem to be extended to stars fainter than the 11^{th} magnitude. From 43 of the BESSEL's stars in the catalogue of LAGRULA, TRÜMLER¹¹⁵ has found that the fainter stars, which have larger proper motions than the brighter ones, show a systematic deviation in proper motions from these, or that the fainter stars seem to rotate in relation to the brighter ones, with a period of about two million years. A drift of the mean of the faint stars relative to the brighter stars has also been discovered by STRATTON¹¹³ but he concludes that the fainter stars are moving with less velocity than the brighter ones, which is to be expected if the motion is a pure parallactic one.

A comparison between the magnitudes and spectral-types, with the photographic and visual magnitudes from SCHWARZSCHILD and MÜLLER und KEMPF and with spectral-types determined by ROSENBERG¹⁰², gives the result that the fainter stars are redder than the brighter ones. TRÜMLER has also examined the relation between magnitudes and colour-index and found a minimum of the colour-index between the visual magnitudes 6^m and 7^m , which had been pointed out earlier by HERTZSPRUNG⁵⁵ and LAU⁷⁸. TRÜMLER, in a later paper¹¹⁶, points out the great range in the luminosities of the Pleiades, in the central region, the brighter stars being 5000 times brighter than the fainter ones. The apparent diameter of the cluster-stars counted in the B. D. charts extends 3° from the centre (Alcyone) and contains 1180 stars, of which $243 < 9^m$. From the great difference in the radial-velocities TRÜMLER concludes that the parallax is $< 0''.002$. He also states that the group contains 15 stars of the magnitudes 6^m_5 to 7^m_5 ¹¹⁸, whose mean type of spectrum is $A 0$, 27 stars 7^m_5 to 8^m_5 , whose mean type is $A 1$, and 29 stars 8^m_5 to 9^m_5 , whose mean type is A . Omitting the 6 "supergiants" of the spectral-type $B 5$, PICKERING⁹⁰ computes for the 5 stars of type $B 8$ and the A -stars the mean absolute magnitude with the formula suggested by RUSSELL¹⁰⁵:—

$$M_0 = 0.6 + 2.1 (t - 2)$$

(t is the type, counting B as 1, A as 2, F as 3, G as 4, K as 5). From this he gets the parallax

$$\pi = 0''.0050 \pm 0''.008.$$

Two different calculations of the parallax have been given by HERTZSPRUNG⁵⁶ in a paper on the nebula in the Pleiades (written on the occasion of a similar paper of SLIPHER¹¹²). From the velocity component in the direction of the antapex he gets:—

$$\pi = 0''.014,$$

and assuming for the stars of spectral-types *B* 5 to *A* 0 an apparent magnitude of $+6^m$ corresponding to an absolute magnitude ($\pi = 1''.0$) of -5^m he gets:—

$$\pi = 0''.0063.$$

(The same value has been found by RUSSELL¹⁰⁶ with the same method.) A direct measure of the parallax exists from Yale Observatory:—

$$\pi = -0''.002 \pm 0''.011.$$

I then take the mean of the parallaxes computed by HAYN, HARTMAN, HERTZSPRUNG, KAPTEYN, PICKERING, PLUMMER, V. SCHOUTEN and TRÜMPER to be

$$\pi = 0''.014.$$

Obtaining the value of the correction *K* from GYLLENBERG (*K* = 0.91 for *B* 5-stars and *K* = 0.26 for *B* 8-stars) the mean value of the radial-velocities will be

$$W = 1.26 \text{ sir./st.}$$

TABLE V.

THE PLEIADES

P.G.C.	Star-name	Sp.	<i>m</i>	<i>α</i>	<i>δ</i>	<i>u</i>	<i>v</i>	<i>w</i>		<i>π</i>	<i>q</i>
								C. C. (sir.)	Voûte (km.)		
851	Electra	<i>B</i> ₅	5.43	54°72	23°97	+ 0.019	— 0.055	+ 3.08	+ 14.6 Y	0.01 (Voûte)	160.7
852		<i>B</i> ₅	3.81	54.72	23.78	+ 0.019	— 0.050				158.9
855		<i>B</i> ₈	5.63	54.80	24.52	+ 0.016	— 0.055				163.4
856	Taygeta	<i>B</i> ₅	4.37	54.83	24.15	+ 0.011	— 0.048	+ 0.63	+ 3 Y		167.2
860	Maia	<i>B</i> ₅	4.02	54.97	24.05	+ 0.029	— 0.045	+ 1.48	+ 6.4 D		147.4
861	Merope	<i>B</i> ₈	5.85	54.97	24.23	+ 0.016	— 0.041	+ 1.27	+ 6 Y		158.2
865		<i>B</i> ₅	4.25	55.10	23.63	+ 0.023	— 0.054				156.6
867		<i>A</i> ₀	8.10	55.35	23.80	+ 0.019	— 0.054				160.6
869	Alcyone	<i>B</i> ₅	2.96	55.37	23.78	+ 0.019	— 0.048	+ 3.17	+ 15 Y		158.1
872	Atlas	<i>B</i> ₃	5.51	55.60	23.10	+ 0.032	— 0.050	+ 2.74	+ 13 Y		147.7
877		<i>B</i> _{8p}	3.80	55.80	23.73	+ 0.019	— 0.050				158.9
879		<i>B</i> _{8p}	5.18	55.80	23.82	+ 0.019	— 0.049				158.5

With the mean proper motion $\bar{\mu} = 0''.054$ I then compute the stream-velocity

$$\Omega = 4.1 \text{ sir./st.} = 19.5 \text{ km./sec.,}$$

with the mean error ± 1.3 sir. and with the equations (2) and (3) in chapter I the convergent:—

$$A = 84^\circ_8 \pm 7^\circ_1, \quad D = -43^\circ_3 \pm 5^\circ_2.$$

The mean absolute magnitude is then for the stars of the spectral-type *B* 5:—

$$M_0 = -1^m_{73}, \quad \sigma = \pm 0^m_{81},$$

and for the *B* 8-stars:—

$$M_0 = -0^m_{71}, \quad \sigma = \pm 0^m_{72}.$$

The absolute motion of the Pleiades is directed towards the point:—

$$A_0 = 292^\circ_0, \quad D_0 = -44^\circ_5,$$

or

$$L_0 = 323^\circ_8, \quad B_0 = -5^\circ_3,$$

with the velocity:—

$$\Omega_0 = 4.8 \text{ km./sec.}$$

The equations (2) and (3) here have the form:—

$$\begin{aligned} -0.456 \alpha + 0.217 \beta + 0.185 \gamma &= 0, \\ +0.523 \alpha + 0.750 \beta + 0.404 \gamma &= 0.307, \\ \alpha^2 + \beta^2 + \gamma^2 &= 1. \end{aligned}$$

$$= 84^\circ_8; D = -43^\circ_3; \Omega = 4.1 \text{ sir./st.}$$

q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
157 ⁵	— 3 ²	72.7	13.88	— 0.28	+ 1.22		0.015		— 8.92	+ 9.21	— 5.82
157.5	— 1.4	72.5	15.09	— 2.08	+ 1.24	— 0.98	0.014		— 9.72	+ 9.98	— 5.81
157.7	— 5.7	73.2	13.92	— 0.09	+ 1.19		0.015		— 8.92	+ 9.32	— 5.22
157.6	— 9.6	72.9	16.47	— 1.71	+ 1.21	+ 1.49	0.013		— 10.60	+ 10.95	— 6.25
157.7	+ 10.3	72.7	15.16	— 1.89	+ 1.22	+ 0.65	0.014		— 9.78	+ 10.05	— 5.75
157.8	— 0.4	72.9	18.84	— 0.47	+ 1.21		0.011		— 11.82	+ 12.20	— 6.91
157.8	+ 1.2	72.4	13.72	— 1.44	+ 1.24	+ 0.88	0.015		— 8.90	+ 9.02	— 5.25
158.0	— 2.6	72.3	14.12	+ 2.85	+ 1.25		0.015		— 9.19	+ 9.29	— 5.34
158.0	— 0.1	72.3	15.62	— 3.01	+ 1.25	— 1.01	0.013	(0.003)	— 10.17	+ 10.27	— 5.91
158.0	+ 10.8	71.6	13.59	— 0.16	+ 1.30		0.015		— 8.93	+ 8.81	— 5.22
158.2	— 0.7	72.1	15.05	— 2.08	+ 1.26	— 1.22	0.014		— 9.88	+ 9.86	— 5.64
158.2	— 0.8	72.2	15.82	— 0.75	+ 1.26		0.014		— 10.05	+ 10.05	— 5.73

CHAPTER VI.

THE PERSEUS-CLUSTER.

(Fig. VI.)

The systematic motion of 16 stars of the spectral-type *B* in Perseus has been pointed out by EDDINGTON⁴², BOSS¹¹ and KAPTEYN⁶⁴. The stars have not the form of a globular cluster, but are arranged in a chain. As was noticed by BACKHOUSE⁷, three of the stars (30 Persei, ϵ Persei and 15 Cameleopardi) are somewhat widely scattered and comparable with Sirius in the Ursa major system. He also proposes that the stars α and σ Persei, which together with some smaller stars belong to the naked-eye cluster, may be included in the moving cluster. No convergent has been determined by these authors, but the motion is observed to be directed neither towards the apex of either drift nor towards the solar antapex.

BOSS¹⁴ assigns the Perseus-cluster together with the Pleiades to his Antapex group with the convergent $A = 107^\circ$, $D = -40^\circ$. This group is practically at rest in space.

The applying of the galactic hypothesis by PLUMMER⁹⁶ gives a rather unsatisfactory result. With only five stars he computes the convergent and the stream-velocity:—

$$A = 106^\circ, \quad D = -30^\circ, \quad \Omega = 14.9 \text{ km./sec.}$$

BOTTLINGER²¹ has in a preliminary paper with 18 stars calculated the convergent:—

$$A = 107^\circ, \quad D = -26^\circ, \quad \Omega = 21.5 \text{ km./sec.}$$

From 7 radial-velocities he determines the zero-point of the radial-velocity to be at $\alpha = 41^\circ$, $\delta = +48^\circ$. The convergence point then lies 90° from this point on a great circle determined by the mean position-angle 131° . He gets the mean-parallax of the group:—

$$\pi = 0''.009,$$

and the mean absolute magnitude of the 17 *B*-stars

$$M_0 = -1.75.$$

For α Persei (*F*) he gets $\pi = 0''.008$ and $M_0 = -5.37$.

On an examination of the proper motions in this region, I have found that the moving cluster is not limited to the naked-eye cluster in Perseus, but that several other stars, especially of the spectral-types *B* and *A* between the limits $\alpha = 0^\circ$ and $\alpha = 80^\circ$, share in the common motion (fig. VI). The stars in the central regions I have arranged in three parallel groups, and for each group the mean of the coefficients *a*, *b* and *c* is calculated and the equations of condition are formed by means of which the convergent is determined.

TABLE VI.

Group	I	II	III
n	5	16	8
$\bar{a}$	— 4.612	— 3.626	— 3.478
$\bar{b}$	— 0.481	— 0.112	+ 0.256
$\bar{c}$	+ 2.106	+ 2.080	+ 2.648

The convergent calculated is:—

$$A = 110^{\circ}_3 \pm 6^{\circ}_1, \quad D = -28^{\circ}_7 \pm 5^{\circ}_4.$$

From the radial-velocities of 15 stars (845 and 1103 excluded) with half weight on the stars 263, 384, 379, 780, 1204 the stream-velocity is computed firstly from the radial-velocities in the catalogue of VOÛTE to be:—

$$\Omega = 4.85 \text{ sir./st.},$$

and secondly from the radial-velocities in the card-catalogue, which gives the value:—

$$\Omega = 4.02 \text{ sir./st.}$$

As final value I then adopt:—

$$\Omega = 4.2 \pm 1.4 \text{ sir./st.}$$

The absolute convergent and stream-velocity is:—

$$A_0 = 99^{\circ}_0, \quad D_0 = +4^{\circ}_1, \quad \Omega_0 = 6.15 \text{ km./sec.}, \\ L_0 = 175^{\circ}_9, \quad B_0 = +1^{\circ}_0.$$

The parallelism with the galactic plane is then very strict.

In table VII the mean absolute magnitudes and the dispersion in the absolute magnitudes of the different spectral-types are collected:—

TABLE VII.

Sp.	n	M_0	σ
B_0-B_5	22	— 1 ^m .88	$\pm 1^m.07$
B_8-B_9	5	— 0.88	± 0.51
A	12	— 0.55	± 0.66
F	1	— 4.76	
K	2	— 2.83	

From the rectangular galactic coordinates (table VIII) I then compute the moments around the medium:—

$$\nu_{11} = +15.812, \quad \nu_{22} = +21.287, \quad \nu_{33} = +6.141, \\ \nu_{12} = +1.111, \quad \nu_{13} = +1.129, \quad \nu_{23} = -0.268.$$

From there I get the equation:—

$$t^3 - 43.12 t^2 + 557.32 t - 1990.04 = 0$$

with the roots:—

$$t_1 = +15.746, \quad t_2 = +21.504, \quad t_3 = +5.868,$$

from which I get the dispersion along the axes:—

$$\alpha_1 = 3.97, \quad \alpha_2 = 4.64, \quad \alpha_3 = 2.42,$$

and the density:—

$$C = 0.031.$$

The frequency function then is:—

$$F = 0.031 \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{15.76} + \frac{y_1^2}{21.40} + \frac{z_1^2}{5.87} \right)}.$$

TABLE VIII.

THE PERSEUS-CLUSTER

P.G.C.	Star-name	Sp.	<i>m</i>	<i>α</i>	<i>δ</i>	<i>u</i>	<i>v</i>	<i>w</i>		<i>π</i>	<i>q</i>
								C. C. (sir.)	Voûte (km.)		
97	λ Cassiop. ...	<i>B</i> ₃	4.88	6°58	+53°97	+0''047	—0''012				104
172	ν " ...	<i>B</i> ₉	5.08	10.80	+50.42	+0.033	—0.011				108
199	γ " ...	<i>B</i> ₉	2.25	12.68	+60.17	+0.029	—0.002	—0.63	—4.7 P, L, D	0''022 F	93
201		<i>B</i> ₈	5.54	12.70	+59.82	+0.040	—0.000				90
263		<i>B</i> ₉	5.46	16.25	+63.67	+0.036	—0.014	—1.81	—6.2 W		111
301		<i>A</i>	6.82	18.60	+64.18	+0.057	—0.014				103
379		<i>B</i> ₈	5.46	24.08	+34.73	+0.043	—0.031	+0.04	+0.2 W		126
384	φ Persei	<i>B</i> ₉	4.19	24.35	+50.18	+0.027	—0.013	+0.68	+3.2 orb.		123
412		<i>B</i> ₈	5.49	26.35	+54.65	+0.034	—0.009				105
419	ε Cassiop.	<i>B</i> ₅	3.44	26.80	+63.17	+0.039	—0.017	—1.90	—7.4 L, Y		113
531		<i>A</i>	5.56	33.58	+49.68	+0.044	—0.023				117
545		<i>K</i>	4.86	34.72	+49.62	+0.027	—0.016	—0.63		{ 0.005 A [0.012]	121
609		<i>A</i>	5.66	38.97	+54.67	+0.050	—0.027				118
639	γ Persei	<i>K</i>	3.98	40.85	+55.47	+0.025	—0.016	—0.84	—1.6 L	[0.020]	122
678		<i>B</i> ₅	5.42	43.43	+51.95	+0.035	—0.027				127
715		<i>A</i>	5.60	45.90	+28.68	+0.029	—0.025				129
740		<i>B</i> ₅	6.38	47.77	+43.65	+0.027	—0.027				134
742		<i>B</i> ₅	5.30	47.87	+49.85	+0.034	—0.030	—1.04	—0.6 W		131
744		<i>B</i> ₅	5.08	48.00	+49.72	+0.032	—0.027				130
767		<i>B</i> ₅	5.30	49.02	+48.85	+0.029	—0.021	—0.20	+3.4 W		126
772	α Persei	<i>F</i> ₅	1.90	49.36	+49.40	+0.028	—0.028	—0.51	—2.4 Y, p, B, L, O, L, W	{ 0.035 F, Sl, M [0.023] 0.017 Ye, Mc	135
774		<i>A</i>	5.64	49.55	+33.17	+0.037	—0.024				123
780		<i>B</i> ₅	4.94	50.22	+48.70	+0.025	—0.020	+1.69	+8.0 L		129
783		<i>B</i> ₅	5.64	50.43	+49.50	+0.043	—0.024				119
787		<i>A</i>	5.60	50.52	+33.45	+0.039	—0.056				145
790		<i>B</i> ₅	4.67	50.55	+49.15	+0.030	—0.033	—1.25	—1.6 W		138
796		<i>B</i> ₈	6.04	50.90	+47.75	+0.033	—0.034				136
802		<i>A</i>	5.52	51.27	+46.67	+0.028	—0.029	—0.61	—2.9 W		116
817	φ Persei	<i>B</i> _{5p}	4.26	52.35	+47.85	+0.036	—0.026	—0.76	+1.0 D, W		126
833		<i>A</i>	5.57	53.65	+37.25	+0.023	—0.022				125
838	δ "	<i>B</i> ₅	3.10	53.95	+47.47	+0.033	—0.033	—0.76	+0.7 W		135
(845)		<i>A</i>	5.57	54.50	+36.13	+0.042	—0.035	+4.60	+21.8 W		127
853		<i>A</i>	5.64	54.75	+45.37	+0.033	—0.015				119
(889)		<i>G</i> ₅	5.92	56.60	+48.35	+0.054	—0.019			{ [0.009] 0.020 W	118
898		<i>B</i> ₅	5.34	57.20	+47.57	+0.032	—0.024	+1.18	+9.9 W		127
910	ε "	<i>B</i> ₀	2.96	57.77	+39.72	+0.027	—0.029			0.003 F	137
947		<i>B</i> _{3p}	4.03	60.35	+47.43	+0.033	—0.030			0.012 G	132
998		<i>A</i>	5.32	63.43	+21.52	+0.036	—0.046				143
1003		<i>B</i> ₈	4.89	63.58	+46.25	+0.024	—0.038	+0.63	+3 L		148
(1093)		<i>A</i>	5.70	68.47	+48.10	+0.039	—0.034	+4.81	+22.8 W		130
1099		<i>A</i>	5.68	68.77	+28.72	+0.044	—0.042				140
1103		<i>A</i>	5.25	68.95	+43.17	+0.045	—0.050	+1.18	+5.6 W		128
1204	η Aurigæ	<i>B</i> ₅	3.28	74.87	+41.08	+0.036	—0.075	+0.63	+3 Y, L		154
1253		<i>B</i> ₅	6.23	77.70	+58.00	+0.022	—0.027				141
1274	ρ "	<i>B</i> ₈	5.12	78.88	+41.70	+0.026	—0.037				144

The directions of the principal axes are then:—

$$\begin{aligned} L_1 &= 348^\circ_3, & B_1 &= -82^\circ_6, \\ L_2 &= 79^\circ_2, & B_2 &= -0^\circ_2, \\ L_3 &= 169^\circ_0, & B_3 &= -6^\circ_6. \end{aligned}$$

The direction of the stream-motion seems to be the same as the direction of the shortest of the axes. The flatness of the cluster has been earlier suspected by TURNER¹¹⁸.

$$= 110^\circ_3; D = -28^\circ_7; \Omega = 4.2 \text{ sir./st.}$$

up	q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
	97.5	— 6.8	120.7	15.2	— 1.08	— 2.14		0.014		+ 0.5	+ 15.0	— 2.0
	102.7	— 5.6	117.6	21.9	— 1.67	— 1.94		0.009		— 0.2	+ 21.4	— 4.5
	99.0	+ 5.1	118.3	26.8	— 4.85	— 2.00	— 0.46	0.008	0.014	— 0.6	+ 26.8	— 0.8
	99.2	+ 9.2	118.3	19.5	— 0.87	— 2.00		0.011		— 0.5	+ 19.2	— 0.7
	100.2	— 11.1	117.2	19.8	— 1.02	— 1.93	— 0.86	0.010		— 1.0	+ 19.8	+ 0.6
	102.0	— 1.8	116.3	13.1	+ 0.78	— 1.86		0.016		— 0.8	+ 13.2	+ 0.6
	116.0	— 10.4	103.1	16.0	— 0.57	— 0.96	— 0.74	0.013		— 3.1	+ 14.0	— 7.0
	112.1	— 11.1	109.2	25.6	— 2.85	— 1.88	— 1.15	0.008		— 3.9	+ 24.7	— 4.8
II	112.8	+ 6.9	109.5	23.8	— 1.85	— 1.89		0.009		— 3.7	+ 22.8	— 2.5
II	109.3	— 4.4	112.6	18.6	— 2.91	— 1.62	+ 1.19	0.011		— 2.4	+ 18.3	+ 0.7
II	118.5	+ 1.1	103.7	16.8	— 0.57	— 1.00		0.012		— 4.3	+ 16.1	— 2.8
II	119.9	— 1.1	102.4	27.4	— 2.83	— 0.90	— 0.27	0.008	0.003	— 7.4	+ 25.9	— 4.4
II	121.4	— 3.0	103.3	14.7	— 0.18	— 0.97		0.014		— 4.1	+ 14.1	— 0.9
II	122.7	+ 0.1	102.8	28.2	— 3.32	— 0.98	— 0.59	0.007	[0.018]	— 8.2	+ 26.9	— 1.2
II	125.1	— 2.6	99.6	19.4	— 1.02	— 0.70		0.011		— 6.4	+ 18.2	— 1.6
II	127.3	— 2.5	84.1	22.7	— 1.13	+ 0.43		0.009		— 11.7	+ 17.2	— 9.1
II	128.8	— 6.1	92.2	22.3	— 0.41	— 0.16		0.009		— 10.0	+ 20.0	— 4.1
II	128.6	— 3.2	96.1	19.1	— 1.11	— 0.45	+ 1.50	0.011		— 7.5	+ 17.1	— 1.7
II	128.7	— 1.9	95.9	20.5	— 1.48	— 0.43		0.010		— 8.2	+ 18.7	— 1.9
II	129.4	+ 3.0	94.8	23.4	— 1.55	— 0.35	+ 0.76	0.009		— 9.7	+ 21.2	— 2.3
II	129.7	— 5.3	95.0	21.6	— 4.76	— 0.36	+ 0.15	0.010	0.015	— 8.8	+ 19.6	— 1.9
II	129.8	+ 6.5	84.5	19.6	— 0.82	+ 0.40		0.011		— 10.4	+ 15.3	— 6.1
II	130.3	+ 1.2	94.2	26.9	— 2.21	— 0.31	— 1.09	0.008		— 11.4	+ 24.3	— 2.5
II	130.4	+ 11.4	94.7	17.6	— 0.59	— 0.34		0.012		— 7.5	+ 16.0	— 1.4
II	130.4	— 14.7	84.1	12.6	+ 0.10	+ 0.43		0.016		— 6.9	+ 9.9	— 3.8
II	130.6	— 7.5	94.2	19.2	— 1.75	— 0.31	+ 1.85	0.011		— 8.2	+ 17.4	— 1.6
II	130.9	— 5.2	93.2	18.4	— 0.28	— 0.23		0.011		— 8.1	+ 16.4	— 1.7
II	131.2	+ 14.7	92.3	21.7	— 1.16	— 0.17	+ 0.44	0.009		— 9.6	+ 19.3	— 2.1
II	131.9	+ 5.9	92.5	19.7	— 2.21	— 0.18	+ 1.49	0.011		— 8.8	+ 17.4	— 1.8
II	132.7	+ 7.0	84.6	27.0	— 1.59	+ 0.39		0.008		— 14.8	+ 21.6	— 6.1
II	133.1	— 2.2	91.4	18.5	— 3.24	— 0.10	+ 1.57	0.011		— 8.7	+ 16.1	— 1.6
II	133.1	+ 6.1	83.3	15.7	— 0.41	+ 0.53	(— 4.07)	0.013		— 8.8	+ 12.3	— 3.6
II	133.7	+ 13.8	89.6	24.1	— 1.27	+ 0.03		0.009		— 11.9	+ 20.7	— 2.6
	135.0	+ 16.3	90.9	15.2	+ 0.01	— 0.06		0.014	0.006	— 7.3	+ 13.3	— 0.8
I	135.4	+ 8.3	90.0	21.7	— 1.34	+ 0.00	— 1.99	0.009		— 10.8	+ 18.4	— 1.3
II	135.6	— 1.7	84.0	21.6	— 3.71	+ 0.44		0.009	0.006	— 12.3	+ 17.3	— 3.3
I	137.8	+ 5.3	88.4	19.2	— 2.39	+ 0.12		0.011	0.001	— 10.0	+ 16.4	— 0.6
II	136.1	— 7.5	67.5	13.8	— 0.38	+ 1.61		0.015		— 10.4	+ 8.0	— 4.3
I	140.2	— 8.1	86.1	19.2	— 1.53	+ 0.29	+ 0.57	0.011		— 10.8	+ 16.0	— 0.4
	144.1	+ 13.3	85.5	16.6	— 0.40	+ 0.33	(— 4.48)	0.012		— 9.4	+ 13.6	+ 0.7
II	141.6	+ 1.5	69.6	13.4	+ 0.04	+ 1.46		0.016		— 10.0	+ 8.5	— 2.4
	144.1	+ 15.7	81.3	12.8	— 0.29	+ 0.63	— 0.55	0.016		— 8.0	+ 9.3	— 0.1
I	148.6	— 5.7	77.1	10.2	— 1.76	+ 0.93	+ 1.21	0.020		— 6.9	+ 7.5	+ 0.3
	151.8	+ 10.5	90.9	24.7	— 0.73	— 0.06		0.008		— 12.1	+ 20.8	+ 5.5
I	151.8	+ 6.9	76.4	18.7	— 1.24	+ 0.98		0.011		— 13.0	+ 13.4	+ 1.4

CHAPTER VII.

THE SCORPIO-CENTAURUS-CLUSTER.

(Fig. VIII.)

The whole number (319) of the helium stars between the galactic latitude $\pm 30^\circ$ and longitude 216° - 360° has been examined by KAPTEYN⁶⁵ in order to get firstly individual parallaxes of the stars and secondly a convergent for the star-motions, on the assumption of a moving cluster in this region. For the region *A* in his paper, which contains 96 stars within the limits $l = 270^\circ$ - 360° , $b = +30^\circ$ - 0° (Centaurus-Scorpius), he computes the mean of the radial-velocities $\bar{W} = +0.8$ km./sec., and with the assumed velocity of the stream $\Omega = 19$ km./sec. he computes the distance of the convergent from the centre of the stars used ($\alpha = 14^h 57^m$, $\delta = -37^\circ_s$) to be $\lambda = 87^\circ_6$ ($19 \cos \lambda = +0.8$). From the coordinates of the centre of the 96 stars ($\alpha = 15^h 4^m$, $\delta = -37^\circ_s$), their mean proper motion $\bar{\mu} = 0''.0432$ and mean position-angle $\bar{q} = 214^\circ_7$, the great circle is defined along which the cluster is moving, and the convergent is:—

$$A = 6^h 35^m, \quad D = -41^\circ_5, \quad \Omega = 15.3 \pm 2.0 \text{ km./sec.}$$

Investigating the other groups in the region he finally arrives at the conclusion that the stars in the whole of the regions which he denotes *A, B, C, D, E, F, G*, have a common motion, and as its definitive vertex he gets:—

$$A = 6^h 18^m, \quad D = -42^\circ, \quad \Omega = 18.3 \pm 0.9 \text{ km./sec.}$$

Only the stars in the constellation VELA do not seem to share in this motion.

Attention is drawn to the pretty strong condensations of stars between galactic longitudes 220° — 240° with the parallax $0''.020$ to $0''.030$, galactic longitudes 260° — 272° , with the parallax $0''.013$ to $0''.017$, galactic longitudes 290° — 325° , with the parallax $0''.008$ to $0''.014$, which shows an indication of a spiral structure.

The star group is strongly limited in space between the distances corresponding to the parallaxes $\pi = 0''.004$ and $\pi = 0''.040$, which is also a proof that we have here to do with a physical group of stars.

KAPTEYN has derived the mean absolute magnitudes for the stars in this group to be:— for the stars of spectral-type *B0-B5*:—

$$M_0 = -0^m_{68}, \quad \sigma = 1^m_8,$$

for the stars of spectral-type *B5-B8*:—

$$M_0 = +0^m_{43}, \quad \sigma = 1^m_{30}.$$

PLUMMER⁹⁶ found for the Scorpio-Centaurus-cluster (24 stars) the convergent:—

$$A = 96^\circ, \quad D = -39^\circ, \quad \Omega = 14.8 \text{ km./sec.,}$$

and for the very doubtful Vela-group (7 stars)

$$A = 93^\circ, \quad D = -38^\circ, \quad \Omega = 15.0 \text{ km./sec.}$$

Using the same method as in chapter VI, I have determined a convergent for the stars of spectral-types *B* and *A* in the Scorpio-Centaurus region, excluding after preliminary attempts the stars that show too great deviations in position-angle. Later I have extended the search for members of the cluster to the neighbouring regions, as is shown in the table. The number of stars in the groups and the mean value of the coefficients can be seen in the following table:—

TABLE IX.

Group	I		II		III	
Sp.	<i>B</i>	<i>A + B</i>	<i>B</i>	<i>A + B</i>	<i>B</i>	<i>A + B</i>
<i>n</i>	30	38	50	59	29	34
$\bar{a}$	+ 3.272	+ 3.250	+ 3.104	+ 3.269	+ 3.542	+ 3.627
$\bar{b}$	— 1.971	— 2.135	— 1.491	— 1.545	— 0.718	— 0.804
$\bar{c}$	— 2.713	— 2.683	— 1.755	— 1.857	— 1.848	— 1.418

From the *B*-stars I shall then have the convergent:—

$$A = 98^\circ_2, \quad D = -43^\circ_6,$$

and from *A*-stars and *B*-stars together:—

$$A = 99^\circ_1 \pm 11^\circ_5, \quad D = -45^\circ_4 \pm 8^\circ_2.$$

The radial-velocities from 38 *B*-stars in the card-catalogue give the stream-velocity:—

$$\Omega = 3.93 \pm 0.50 \text{ sir./st.}$$

The absolute motion of the group will then be towards the point:—

$$A_0 = 244^\circ_6, \quad D_0 = -33^\circ_3, \quad \Omega_0 = 5.7 \text{ km./sec.,} \\ L_0 = 313^\circ_7, \quad B_0 = +9^\circ_8.$$

The absolute magnitudes of the stars of different types and sub-types are gathered in the following table:—

TABLE X.

Sp.	<i>N</i>	<i>M</i> ₀	σ
<i>B</i> ₀ - <i>B</i> ₃	93	— 2 ^m .07	$\pm 1^m.24$
<i>B</i> ₈ - <i>B</i> ₉	33	— 0.61	± 0.77
<i>A</i>	23	— 0.20	± 0.73
<i>B</i> ₁ - <i>B</i> ₂	17	— 3.36	

TABLE XI.

THE SCORPIO-CENTAURUS-CLUSTER

P.G.C.	Star-name	Sp.	<i>m</i>	α	δ	<i>u</i>	<i>v</i>	<i>w</i>		π	<i>q</i>
								C. C. (sir.)	Voûte (km.)		
2179	ϵ Volantis ...	<i>B</i> ₅	4.46	121° 90	— 68° 32	— 0" 018	+ 0" 022	+ 2.32			140.
2320		<i>A</i>	5.17	129.20	— 39.90	— 0.064	— 0.012				79.
2340		<i>B</i> ₉	5.68	129.85	— 52.73	— 0.033	+ 0.016				115.
2341		<i>B</i> ₅	5.04	129.90	— 52.75	— 0.026	+ 0.002	+ 4.10			94.
2428		<i>B</i> ₅	5.54	134.40	— 41.47	— 0.046	— 0.002	+ 6.76			87.
2472		<i>B</i> ₀	5.92	137.00	— 46.10	— 0.028	— 0.006				77.
2473		<i>B</i> ₈	3.56	137.08	— 58.55	— 0.040	— 0.005	+ 3.38	+ 23.3 orb.		97.
2477		<i>B</i> ₈	4.18	137.25	— 61.90	— 0.049	+ 0.005	+ 3.38	+ 16 L		95.
2483		<i>B</i> ₈	5.15	137.68	— 42.80	— 0.034	— 0.001				88.
2526	α Velorum ...	<i>B</i> ₈	2.63	139.75	— 54.60	— 0.020	— 0.005	+ 4.62			75.
2674	ϕ " ...	<i>B</i> ₅	3.70	148.33	— 54.08	— 0.022	— 0.006	+ 3.04	+ 14.4 L		74.
2733	ω Carinæ ...	<i>B</i> ₈	3.56	152.85	— 69.53	— 0.027	— 0.002				86.
2811		<i>B</i> _{5p}	3.58	157.12	— 61.17	— 0.026	+ 0.007	+ 5.07			105.
(2961)		<i>A</i>	5.42	166.10	— 61.46	— 0.034	— 0.001	— 4.86?	— 23 L		91.
2969		<i>B</i> ₉	5.52	167.15	— 63.62	— 0.028	— 0.006				77.
2992	π Centauri ..	<i>B</i> ₅	4.26	169.10	— 53.93	— 0.036	— 0.018				63.
3016		<i>A</i>	5.54	170.52	— 60.55	— 0.032	— 0.007				77.
3048		<i>B</i> ₈	4.82	172.50	— 53.70	— 0.066	— 0.003	+ 2.53	+ 12 L		87.
3054	λ Centauri ...	<i>B</i> ₉	3.34	172.80	— 62.45	— 0.041	— 0.022	+ 2.32	+ 11 L		61.
(3071)		<i>A</i>	5.08	173.72	— 64.83	— 0.031	— 0.021				55.
3111		<i>B</i> ₈	5.10	176.75	— 64.63	— 0.036	— 0.015	+ 4.43	+ 21 L		67.
(3134)	ϵ Chamæl. ...	<i>B</i> ₉	5.05	178.68	— 77.65	— 0.040	— 0.017				66.
(3152)		<i>A</i>	5.42	179.87	— 67.77	— 0.038	— 0.026				55.
3162		<i>B</i> ₅	4.81	180.72	— 50.10	— 0.029	— 0.005	+ 3.46	+ 16.4 L		80.
3163		<i>A</i>	5.58	180.77	— 48.13	— 0.029	— 0.034				40.
3165	δ Centauri ..	<i>B</i> _{5p}	2.88	180.80	— 50.15	— 0.039	— 0.017				66.
3167		<i>A</i>	5.93	180.93	— 43.77	— 0.065	— 0.067				44.
3168		<i>B</i> ₀	5.62	180.93	— 40.67	— 0.024	— 0.017				54.
3176	ρ " ...	<i>B</i> ₈	4.20	181.60	— 51.80	— 0.044	— 0.022	+ 5.91	+ 28 L		63.
3187	δ Crucis	<i>B</i> ₈	3.08	182.45	— 58.18	— 0.043	— 0.019	+ 5.28	+ 25 L		65.
3200	ζ "	<i>B</i> ₈	4.26	183.25	— 63.43	— 0.047	— 0.019	+ 4.20	+ 19.9 L		68.
3222		<i>A</i>	5.59	184.85	— 57.12	— 0.052	— 0.031				59.
3227		<i>B</i> ₉	5.42	184.58	— 34.85	— 0.036	— 0.025				54.
3232		<i>B</i> ₉	5.77	185.02	— 34.62	— 0.041	— 0.013				65.
(3236)		<i>B</i> ₅	5.14	185.25	— 62.57	— 0.035	— 0.040				41.
3237	α_1 "	<i>B</i> ₁	1.58	185.25	— 62.53	— 0.035	— 0.031	+ 1.48	+ 19 L	} 0.055 G	48.
3238	α_2 "	<i>B</i> ₁	2.09	185.25	— 62.53	— 0.045	— 0.016		+ 19 L		70.
3239		<i>B</i> ₈	5.04	185.27	— 50.88	— 0.069	— 0.037				61.
3245	σ Centauri ..	<i>B</i> ₈	4.16	185.65	— 49.67	— 0.037	— 0.028				53.
3249		<i>B</i> ₉	5.60	185.77	— 38.48	— 0.026	— 0.016				58.
3269	γ Muscæ	<i>B</i> ₅	4.04	186.62	— 71.57	— 0.043	— 0.013				73.
3289	α "	<i>B</i> ₈	2.94	187.80	— 68.58	— 0.037	— 0.021	+ 2.85	+ 13.5 L	} 0.008 G	60.
3300		<i>B</i> ₈	4.79	188.62	— 39.43	— 0.047	— 0.043	+ 2.74	+ 13 L		47.
3305		<i>B</i> ₈	5.02	189.05	— 59.13	— 0.022	— 0.012	+ 4.12	+ 19.5 L		61.
3312		<i>B</i> ₉	6.23	189.28	— 55.38	— 0.041	— 0.033				51.
3314		<i>B</i> ₈	6.25	189.38	— 55.62	— 0.041	— 0.027				56.
(3320)	β "	<i>B</i> ₈	3.26	190.02	— 67.55	— 0.029	— 0.029				44.
3324		<i>B</i> ₈	4.86	190.15	— 55.93	— 0.039	— 0.040	+ 3.84	+ 18.2 L	} 0.008 G	44.
3328	β Crucis	<i>B</i> ₁	1.50	190.47	— 59.13	— 0.048	— 0.028	+ 2.74	+ 13 L		59.
3341		<i>A</i>	5.90	191.30	— 52.33	— 0.025	— 0.038				42.
3342		<i>A</i>	5.01	191.33	— 33.45	— 0.038	— 0.036				46.
3345		<i>B</i> ₈	6.14	191.35	— 39.13	— 0.037	— 0.038				44.
(3357)	λ "	<i>B</i> ₈	4.84	192.18	— 58.60	— 0.032	— 0.039				39.
3358	μ_1 "	<i>B</i> ₈	4.26	192.18	— 58.63	— 0.033	— 0.013				68.
3359	μ_2 "	<i>B</i> _{8p}	5.46	192.18	— 56.62	— 0.021	— 0.017	+ 1.48	+ 13.2 L		51.
3366		<i>O</i> ₆₅	5.58	192.52	— 56.28	— 0.036	— 0.026		+ 7 L		54.
3369		<i>B</i> ₈	5.29	192.83	— 50.65	— 0.037	— 0.037				44.
3384		<i>A</i>	5.02	194.45	— 48.98	— 0.052	— 0.029				60.
3390		<i>B</i> ₈	4.96	195.12	— 47.92	— 0.040	— 0.044				42.

$= 99^{\circ}1$; $D = -45^{\circ}4$; $\Omega = 3.9$ sir./st.

Group	q	Δq	λ	r	M	w_e	Δw	π_e	$\Delta \pi$	x	y	z
	141.4	+ 0°8	26°2	12.6	-1.04	+ 3.49	+ 2.08	0.016		-4.3	-11.1	-4.0
	67.0	-12.4	22.7	4.7	+1.83	+ 3.62		0.044		-3.1	-3.5	+0.1
	98.6	-17.0	21.6	8.1	+1.13	+ 3.65		0.025		-4.3	-6.9	-0.9
	98.6	+ 4.2	21.6	11.4	-0.24	+ 3.65	+ 0.26	0.018		-6.0	-9.6	-1.2
	70.2	-15.3	25.8	7.6	+1.14	+ 3.54	-2.31	0.027		-4.7	-6.0	+0.5
	78.4	+ 0.7	26.4	12.6	+0.42	+ 3.52		0.016		-7.0	-10.5	+0.4
	103.6	+ 6.5	26.7	9.0	-1.21	+ 3.51	+ 1.04	0.023		-3.8	-8.1	-1.1
	109.7	+13.8	27.7	7.7	-0.25	+ 3.43	+ 1.01	0.027		-2.9	-7.0	-1.2
	72.0	-16.3	27.7	11.1	-0.08	+ 3.48		0.019		-6.4	-9.0	+0.9
	93.3	+17.5	27.6	18.2	-3.67	+ 3.48	-0.33	0.011		-8.1	-16.3	-1.0
	85.6	+11.0	32.5	19.8	-2.78	+ 3.31	+ 1.18	0.010		-7.7	-18.2	+0.1
	104.0	+17.1	36.1	17.6	-2.66	+ 3.18		0.012		-3.7	-16.8	-3.4
	88.7	-16.6	36.9	18.1	-2.71	+ 3.14	-1.02	0.011		-4.7	-17.4	-1.0
(I)	81.5	-10.2	41.2	15.9	-0.59	+ 2.95		0.013		-3.1	-15.6	-0.4
I	83.4	+ 5.5	41.4	18.7	-0.84	+ 2.95		0.011		-3.2	-18.4	-1.1
I	71.6	+ 8.1	44.5	14.1	-1.49	+ 2.80		0.015		-3.0	-13.7	+1.5
I	77.2	- 0.4	43.5	16.5	-0.55	+ 2.85		0.013		-2.7	-16.3	+0.0
I	69.3	-18.1	46.5	8.9	+0.08	+ 2.70	+ 0.43	0.023		-1.6	-8.8	+1.1
II	77.4	+15.7	44.2	12.2	-2.08	+ 2.81	-0.75	0.017		-1.7	-12.0	-0.3
(II)	79.0	+23.6	44.0	15.1	-0.81	+ 2.83		0.014		-1.8	-14.9	-1.0
II	76.4	+ 9.3	45.3	14.8	-0.75	+ 2.76	-1.41	0.014		-1.5	-14.7	-0.8
III	87.7	+20.8	44.1	13.0	-0.51	+ 2.82		0.016		-0.5	-12.5	-3.6
III	76.8	+21.4	45.8	12.6	-0.08	+ 2.74		0.016		-0.9	-12.5	-1.3
I	61.8	-18.5	52.6	21.9	-1.89	+ 2.39	-0.16	0.009		-2.3	-21.3	+4.4
I	60.5	+20.5	53.5	16.4	-0.51	+ 2.34		0.013		-1.8	-15.3	+3.3
I	61.8	- 4.5	52.6	15.1	-3.02	+ 2.39		0.014		-1.5	-14.6	+3.0
I	57.7	+13.7	55.9	8.1	+1.40	+ 2.20		0.026		-0.9	-7.6	+2.5
I	56.0	+ 1.5	57.6	23.3	-1.22	+ 2.10		0.009		-2.8	-21.6	+8.3
I	62.4	- 1.2	52.3	13.0	-1.36	+ 2.40	-2.60	0.016		-1.2	-12.7	+2.2
II	66.6	+ 0.7	50.0	13.4	-2.55	+ 2.52	-1.85	0.015		-0.9	-13.3	+0.8
II	70.2	+ 2.1	48.4	12.0	-1.13	+ 2.61	-0.68	0.017		-0.6	-11.9	-0.3
II	64.5	+ 5.1	51.3	10.5	+0.50	+ 2.46		0.020		-0.6	-10.4	+0.9
I	52.1	- 2.8	63.4	16.5	-0.67	+ 1.76		0.013		-1.3	-14.6	+7.5
I	51.9	-14.0	63.8	16.9	-0.37	+ 1.73		0.012		-1.2	-15.0	+7.7
(II)	68.0	+26.5	49.5	11.6	-0.18	+ 2.55		0.018		-0.4	-11.6	-0.1
II	68.0	+19.8	49.5	13.2	-1.53	+ 2.55	+ 1.98	0.016	0.039	-0.5	-13.2	-0.1
II	68.0	- 2.4	49.6	12.9	-3.46	+ 2.51		0.016		-0.5	-12.9	-0.1
I	59.8	- 2.0	54.7	8.5	+0.40	+ 2.27		0.024		-0.4	-8.3	+1.6
I	58.9	+ 5.7	55.5	14.1	-1.70	+ 2.22		0.015		-0.7	-13.7	+3.0
I	52.4	- 5.6	63.1	23.7	-1.27	+ 1.78		0.009		-1.4	-21.7	+9.4
III	74.5	+ 1.5	47.0	13.2	-1.54	+ 2.68		0.016		-0.3	-13.0	-2.2
III	70.9	+10.7	48.4	14.3	-2.83	+ 2.61	+ 0.67	0.015		-0.1	-14.2	-1.6
I	52.5	+ 5.2	63.1	11.4	-0.50	+ 1.78	-0.70	0.018		-0.2	-10.5	+4.4
II	62.8	+ 1.8	52.7	26.1	-2.06	+ 2.38	-1.48	0.008		-0.2	-26.1	+1.3
II	59.6	+ 8.2	55.1	12.6	+0.73	+ 2.25		0.016		-0.1	-12.5	+1.4
II	60.3	+ 4.6	54.5	13.5	+0.59	+ 2.23		0.015		-0.1	-13.5	+1.5
(III)	68.3	+23.6	49.6	15.1	-2.62	+ 2.55		0.014		+0.0	-15.0	-1.5
II	60.0	+15.9	54.7	11.9	-0.51	+ 2.27	-0.66	0.017		+0.0	-11.8	-1.3
II	61.9	+ 2.2	53.3	11.7	-3.34	+ 2.35	+ 0.52	0.018	0.010	+0.1	-11.7	+0.6
I	57.2	+15.1	57.1	18.1	-0.39	+ 2.13		0.011		+0.3	-17.9	+3.1
I	49.4	+ 3.0	68.5	14.4	-0.78	+ 1.44		0.014		+0.3	-12.7	+6.9
I	51.3	+ 6.8	65.1	13.8	+0.44	+ 1.65		0.015		+0.3	-12.7	+5.4
(II)	60.4	+21.3	54.3	12.8	-0.70	+ 2.29		0.016		+0.3	-12.3	+0.8
II	60.4	- 8.6	54.3	18.7	-2.10	+ 2.29		0.011		+0.4	-18.7	+1.1
II	59.1	+ 7.7	55.6	24.5	-1.49	+ 2.22	+ 1.65	0.008		+0.5	-24.4	+2.3
	58.7	+ 4.5	55.7	15.1	-0.31	+ 2.21		0.014		+0.4	-15.0	+1.5
I	55.5	+10.7	58.9	13.3	-0.33	+ 2.03		0.016		+0.4	-13.0	+2.6
I	53.8	- 7.1	60.7	11.9	-0.35	+ 1.92		0.017		+0.6	-11.6	+2.7
I	53.0	+10.8	61.7	12.0	-0.44	+ 1.86		0.017		+0.7	-11.6	+2.9

P.G.C.	Star-name	Sp.	<i>m</i>	<i>α</i>	<i>δ</i>	<i>u</i>	<i>v</i>	<i>w</i>		<i>π</i>	<i>q</i>
								C. C. (sir.)	Voûte (km.)		
3393	ξ Centauri .	<i>B</i> ₃	4.40	195°27	— 49°37	— 0''085	— 0''024				55.
3400		<i>A</i>	5.96	195.48	— 52.92	— 0.043	— 0.082				53.
3419		<i>B</i> ₃	4.76	196.50	— 59.88	— 0.052	— 0.084				56.
3429	γ Muscæ	<i>B</i> ₃	4.95	197.12	— 67.85	— 0.025	— 0.019				53.
(3451)		<i>B</i> ₃	5.70	198.65	— 52.22	— 0.080	— 0.048				31.
3456		<i>B</i> ₃	6.51	199.02	— 60.45	— 0.017	— 0.023				36.
3457		<i>B</i> ₃	4.62	199.05	— 60.45	— 0.084	— 0.019				60.
3521	ε Centauri...	<i>B</i> ₁	2.56	203.87	— 52.95	— 0.031	— 0.027	+ 1.27	+ 6 L		48.
3528		<i>B</i> ₀	5.40	203.88	— 54.05	— 0.041	— 0.054				37.
3529		<i>A</i>	5.58	203.85	— 58.27	— 0.039	— 0.026				56.
(3535)		<i>B</i> ₀	6.80	204.10	— 56.27	— 0.011	— 0.021				28.
3564	ν "	<i>B</i> ₃	3.58	205.87	— 41.18	— 0.084	— 0.025	+ 2.16	+ 9.0 orb.		53.
3565	μ "	<i>B</i> _{2p}	3.32	205.90	— 41.97	— 0.028	— 0.018		+ 12.6 L		51.
3575		<i>B</i> ₃	5.87	206.40	— 46.40	— 0.021	— 0.089				27.
3576		<i>B</i> ₃	5.42	206.40	— 52.80	— 0.049	— 0.045	+ 2.98			47.
3577		<i>B</i> ₅	4.72	206.52	— 32.48	— 0.045	— 0.039				49.
(3578)		<i>B</i> ₅	6.17	206.52	— 32.48	— 0.067	— 0.037		14.1 L		23.
3592		<i>B</i> ₃	5.84	207.20	— 51.67	— 0.049	— 0.032				56.
3593	ζ "	<i>B</i> _{2p}	3.06	207.83	— 46.78	— 0.061	— 0.053				49.
3602	Φ "	<i>B</i> ₃	4.05	208.05	— 41.60	— 0.027	— 0.020	+ 1.12	+ 5.3 L		53.
3603	υ "	<i>B</i> ₃	4.17	208.12	— 44.80	— 0.033	— 0.032	+ 0.84	+ 4 L	0.037 G	45.
3615	β "	<i>B</i> ₁	0.86	209.20	— 59.88	— 0.027	— 0.032	+ 2.53			40.
3621	χ "	<i>B</i> ₃	4.54	209.97	— 40.70	— 0.018	— 0.034	+ 2.62	+ 12.4 L		28.
3643		<i>B</i> _{3p}	5.20	212.00	— 56.62	— 0.033	— 0.014				66.
3646		<i>B</i> ₃	5.88	212.18	— 66.12	— 0.015	— 0.009				58.
3670	υ "	<i>B</i> ₅	4.41	213.83	— 55.92	— 0.025	— 0.021	+ 0.74	+ 3.5 L		50.
3688		<i>B</i> ₅	4.55	214.22	— 39.05	— 0.028	— 0.040	+ 1.94	+ 9.2 L		35.
3707		<i>B</i> ₃	5.00	215.88	— 29.03	— 0.025	— 0.033				36.
3712		<i>A</i> ₂	5.52	215.93	— 49.07	— 0.046	— 0.053				38.
3713		<i>B</i> ₀	5.49	215.93	— 44.87	— 0.044	— 0.053				39.
3724	γ "	<i>B</i> _{3p}	2.65	217.80	— 41.72	— 0.084	— 0.035	+ 0.00	+ 0.0 L		44.
3732	ρ Lupi	<i>B</i> ₅	4.14	217.80	— 48.98	— 0.035	— 0.037				43.
3745	α "	<i>B</i> ₂	2.89	218.83	— 46.95	— 0.022	— 0.028	+ 1.69			37.
3747		<i>B</i> ₃	4.09	218.93	— 37.35	— 0.018	— 0.040				24.
3783	ο "	<i>B</i> ₅	4.49	221.27	— 43.15	— 0.035	— 0.035	+ 1.52	+ 7.2 L		45.
(3796)		<i>B</i> ₃	5.11	221.65	— 37.88	— 0.038	— 0.020				62.
3808		<i>B</i> ₃	5.78	222.43	— 47.47	— 0.026	— 0.027				43.
3815	β "	<i>B</i> _{2p}	2.81	223.00	— 42.72	— 0.047	— 0.051	+ 0.00			42.
3818	κ Centauri...	<i>B</i> ₃	3.35	223.18	— 41.70	— 0.017	— 0.032	+ 2.11			28.
3832		<i>B</i> ₅	5.45	224.22	— 32.23	— 0.038	— 0.051	+ 0.84	+ 4 L		36.
3838	π Lupi	<i>B</i> ₅	4.72	224.58	— 46.65	— 0.023	— 0.033				34.
3852	λ "	<i>B</i> ₃	4.39	225.52	— 44.88	— 0.024	— 0.020				50.
3865		<i>B</i> ₃	4.92	226.52	— 44.12	— 0.038	— 0.033				49.
3888	μ "	<i>B</i> ₃	4.86	227.90	— 47.50	— 0.032	— 0.050				32.
3889		<i>B</i> ₅	4.72	227.90	— 47.50	— 0.014	— 0.042				18.
3892		<i>B</i> ₃	5.78	228.10	— 40.42	— 0.025	— 0.032	+ 4.43	+ 21 L		37.
(3901)	γ Circini	<i>B</i> _{3p}	4.54	228.85	— 58.95	— 0.010	— 0.042				13.
3905	ε Lupi	<i>B</i> ₃	3.74	228.97	— 44.32	— 0.016	— 0.023				32.
3910		<i>B</i> ₃	4.69	229.20	— 36.43	— 0.022	— 0.031				34.
3916	υ "	<i>A</i>	5.38	229.55	— 39.55	— 0.044	— 0.058	— 1.90	— 9 L		37.
3950	γ "	<i>B</i> ₃	2.95	232.12	— 40.82	— 0.016	— 0.036				37.
3956		<i>B</i> ₃	5.76	232.33	— 73.10	— 0.015	— 0.018				40.
3965		<i>B</i> ₀	5.48	232.85	— 52.03	— 0.033	— 0.042				37.
3973	τ Libræ	<i>B</i> ₃	3.80	233.12	— 29.43	— 0.024	— 0.033				35.
3991		<i>B</i> ₅	4.82	234.08	— 34.38	— 0.032	— 0.037				40.
4006		<i>B</i> ₃	5.61	235.08	— 34.37	— 0.015	— 0.022				33.
4011		<i>B</i> ₀	5.96	235.62	— 52.90	— 0.037	— 0.039				43.
4019		<i>B</i> ₃	4.77	236.25	— 25.43	— 0.023	— 0.035				33.
4033	λ "	<i>A</i>	5.06	236.87	— 19.87	— 0.014	— 0.034				22.
4034		<i>B</i> ₃	4.66	236.90	— 25.02	— 0.012	— 0.032				20.
4036		<i>A</i>	5.96	236.98	— 60.18	— 0.032	— 0.038				20.
(4037)		<i>A</i>	5.44	236.97	— 24.23	— 0.036	— 0.029				50.
4038		<i>G</i>	5.36	237.00	— 23.67	— 0.026	— 0.039				33.

Group	q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
I	53.6	- 2.3	60.9	16.5	- 1.69	+ 1.91		0.013		+ 1.0	- 16.1	+ 3.6
II	55.1	+ 1.6	58.9	12.9	+ 0.41	+ 2.03		0.016		+ 0.7	- 12.8	+ 2.0
III	57.9	+ 1.2	55.9	10.8	- 0.41	+ 2.20		0.019		+ 0.6	- 10.8	+ 0.5
(II)	62.5	+ 9.4	53.1	20.4	- 1.60	+ 2.41		0.010		+ 1.0	- 20.3	+ 2.0
III	52.9	+ 21.2	60.9	12.5	+ 0.21	+ 1.91		0.017		+ 1.2	- 12.3	+ 2.0
III	56.8	+ 20.8	60.9	23.6	- 0.35	+ 1.91		0.009		+ 1.8	- 23.5	+ 0.5
III	56.8	- 3.6	56.3	17.5	- 1.60	+ 2.18		0.012		+ 1.4	- 17.5	+ 0.4
II	50.4	+ 1.7	62.7	17.6	- 3.67	+ 1.80	+ 1.44	0.012		+ 2.5	- 17.3	+ 2.5
II	50.6	+ 13.2	62.2	10.5	+ 0.28	+ 1.88		0.020		+ 1.5	- 10.4	+ 1.3
III	52.4	- 3.6	59.6	14.9	- 0.84	+ 1.99		0.014		+ 1.9	- 14.8	+ 0.8
(II)	51.4	+ 22.9	60.9	29.9	- 1.08	+ 1.91		0.007		+ 4.0	- 29.5	+ 2.5
I	45.4	- 8.3	71.9	18.3	- 2.78	+ 1.22	- 0.03	0.011		+ 3.8	- 16.8	+ 6.0
I	45.6	- 6.0	71.2	26.5	- 3.79	+ 1.26		0.008		+ 5.4	- 24.6	+ 8.4
I	46.5	+ 18.8	68.5	17.1	- 0.30	+ 1.44		0.012		+ 3.3	- 16.3	+ 4.2
II	48.4	+ 1.1	64.5	11.0	+ 0.21	+ 1.69	- 1.03	0.019		+ 1.9	- 10.7	+ 1.6
I	43.5	- 5.8	78.5	13.4	- 0.91	+ 0.78		0.015		+ 3.2	- 11.4	+ 6.2
I	43.5	+ 19.7	78.5	10.4	+ 1.08	+ 0.78		0.020		+ 2.5	- 8.9	+ 4.8
II	47.7	- 9.2	65.3	12.6	+ 0.34	+ 1.60		0.016		+ 2.3	- 12.2	+ 2.0
I	46.0	- 3.3	68.9	9.8	- 1.79	+ 1.41		0.022		+ 1.9	- 8.9	+ 2.2
I	44.4	- 9.8	72.7	22.9	- 2.75	+ 1.17	+ 0.96	0.009		+ 5.3	- 21.1	+ 7.2
I	45.0	- 0.8	70.8	16.7	- 1.94	+ 1.29	+ 1.36	0.012	0.025	+ 3.7	- 15.6	+ 4.6
III	49.5	+ 9.3	60.7	16.9	- 5.28	+ 1.92	+ 0.30	0.012		+ 2.8	- 16.6	+ 0.2
I	43.3	+ 15.3	74.5	20.2	- 1.99	+ 1.05	- 0.67	0.010		+ 5.2	- 18.4	+ 6.5
III	46.4	- 20.4	64.0	20.5	- 1.36	+ 1.68		0.010		+ 4.2	- 20.0	+ 1.2
III	50.1	- 8.1	57.9	39.2	- 2.09	+ 2.09		0.005		+ 6.0	- 39.0	- 3.9
III	45.3	- 4.7	65.0	22.5	- 2.35	+ 1.66	+ 1.33	0.009		+ 5.0	- 21.8	+ 1.5
I	40.9	+ 5.9	77.7	16.2	- 4.55	+ 0.84	- 0.19	0.013		+ 5.2	- 14.4	+ 5.4
I	39.2	+ 2.3	86.6	19.6	- 1.46	+ 0.23		0.011		+ 7.5	- 15.6	+ 9.1
II	41.8	+ 3.3	71.1	10.4	+ 0.44	+ 1.27		0.020		+ 4.0	- 9.8	+ 1.7
II	40.9	+ 1.5	74.8	11.4	+ 0.21	+ 1.06		0.013		+ 3.5	- 10.5	+ 2.6
I	39.7	- 4.5	77.2	16.2	- 3.40	+ 0.87	+ 1.78	0.013		+ 5.5	- 14.6	+ 4.4
II	40.7	- 3.0	72.0	15.1	- 1.75	+ 1.21		0.014		+ 4.6	- 14.1	+ 2.4
II	39.7	+ 2.1	73.9	22.0	- 3.83	+ 1.09	+ 0.31	0.009		+ 7.3	- 20.4	+ 4.1
I	38.8	+ 14.1	81.5	18.3	- 2.22	+ 0.58		0.011		+ 7.0	- 15.7	+ 6.0
II	37.7	- 7.4	78.0	16.0	- 1.53	+ 0.82	+ 0.21	0.013		+ 6.1	- 14.3	+ 3.7
(I)	36.9	- 25.6	82.8	18.7	- 1.26	+ 0.49		0.011		+ 7.8	- 16.0	+ 5.9
II	37.7	- 5.8	75.1	21.1	- 0.84	+ 1.01		0.010		+ 7.6	- 19.3	+ 3.3
II	36.7	- 6.0	79.1	11.5	- 2.49	+ 0.74	+ 1.65	0.018		+ 4.6	- 10.2	+ 2.6
II	36.5	+ 8.5	79.9	22.0	- 3.37	+ 0.69	- 0.51	0.009		+ 9.0	- 19.4	+ 5.8
II	35.3	- 1.2	87.7	12.8	- 0.08	+ 0.16	+ 0.23	0.016		+ 6.1	- 10.2	+ 4.7
II	36.3	+ 2.0	76.6	19.8	- 1.76	+ 0.91		0.010		+ 7.7	- 17.9	+ 3.1
II	35.5	- 15.2	78.4	25.2	- 2.61	+ 0.79		0.008		+ 10.4	- 22.5	+ 4.5
II	34.8	- 14.4	79.5	15.8	- 1.06	+ 0.72		0.013		+ 6.7	- 14.0	+ 2.9
II	34.4	+ 2.0	77.2	13.3	- 1.27	+ 0.87		0.016		+ 5.5	- 12.0	+ 1.7
II	34.4	+ 15.6	77.1	13.3	- 0.90	+ 0.88		0.016		+ 5.5	- 12.0	+ 1.7
II	33.6	- 4.8	83.2	19.9	- 0.71	+ 0.46	- 3.71	0.010		+ 9.8	- 16.9	+ 4.5
II	35.8	+ 22.6	68.1	17.4	- 1.56	+ 1.47		0.012		+ 5.6	- 16.5	- 0.8
II	33.4	+ 0.7	80.3	28.5	- 3.54	+ 0.66		0.007		+ 12.8	- 25.0	+ 4.7
II	32.8	- 2.1	86.8	21.4	- 1.96	+ 0.22		0.010		+ 10.9	- 17.5	+ 5.8
II	32.9	- 4.5	82.0	11.0	+ 0.17	+ 0.55	+ 2.07	0.019		+ 5.4	- 9.8	+ 2.5
II	31.2	- 6.5	85.8	20.5	- 3.61	+ 0.29		0.010		+ 10.4	- 17.3	+ 3.9
III	37.5	- 2.9	57.6	29.2	- 1.57	+ 2.10		0.007		+ 5.7	- 27.7	- 7.6
II	31.8	- 5.9	75.2	14.7	- 0.36	+ 0.99		0.014		+ 6.2	- 13.4	+ 0.4
II	30.6	- 4.9	94.6	19.9	- 2.70	- 0.32		0.010		+ 11.9	- 14.6	+ 6.6
II	30.0	- 10.8	90.8	16.6	- 1.28	- 0.06		0.012		+ 9.5	- 12.9	+ 4.3
II	29.4	- 4.4	91.2	30.5	- 1.31	- 0.08		0.007		+ 17.8	- 23.5	+ 7.6
III	30.3	- 13.2	75.7	14.6	+ 0.14	+ 0.97		0.014		+ 6.3	- 13.2	- 0.0
II	29.1	- 4.2	99.7	18.9	- 1.62	- 0.66		0.011		+ 12.3	- 12.7	+ 6.6
II	29.4	+ 6.9	104.7	21.3	- 1.58	- 1.00		0.010		+ 14.6	- 12.8	+ 8.7
II	28.8	+ 7.9	79.9	23.3	- 2.18	+ 0.69		0.009		+ 15.4	- 15.5	+ 8.1
(II)	30.4	+ 10.4	69.4	8.1	+ 1.42	+ 1.33		0.025		+ 2.9	- 7.5	- 0.9
	28.8	- 22.0	100.9	17.2	- 0.74	- 0.74		0.012		+ 11.5	- 11.8	+ 6.2
	28.9	- 4.9	101.4	16.9	- 0.78	- 0.78		0.012		+ 11.3	- 11.0	+ 6.2

P.G.C.	Star-name	Sp.	<i>m</i>	α	δ	<i>u</i>	<i>v</i>	<i>w</i>		π	<i>q</i>
								C. C. (sir.)	Voûte (km.)		
4041		<i>A</i>	5.98	237°18	— 24.98	— 0''014	— 0''031				23°8
4043		<i>A</i>	5.90	237.30	— 19.08	— 0.024	— 0.039				31.6
4052	ρ Scorpii	<i>B</i> ₃	4.02	237.68	— 28.92	— 0.013	— 0.030	+ 0.68	+ 3.2 L		26.0
4062	π »	<i>B</i> _{2p}	3.00	238.20	— 25.82	— 0.015	— 0.036				22.5
4064	η Lupi	<i>B</i>	3.61	238.37	— 38.10	— 0.020	— 0.039				26.9
4066	δ Scorpii	<i>B</i> ₀	2.54	238.60	— 22.33	— 0.013	— 0.039			0.008 F	17.8
4076		<i>B</i> ₅	4.97	239.20	— 38.32	— 0.026	— 0.035	+ 1.06	+ 5 L		36.2
4086	β_1 »	<i>B</i> ₁	2.90	239.90	— 19.52	— 0.011	— 0.029		— 9.5 orb.	0.009 F	21.3
4087	β_2 »	<i>B</i> ₁	5.06	239.90	— 19.52	— 0.023	— 0.025			0.009 F	42.1
4091	θ Lupi	<i>B</i> ₃	4.33	240.00	— 36.52	— 0.020	— 0.035				30.2
4092		<i>F</i>	5.94	240.02	— 23.33	— 0.023	— 0.048				26.0
4093	ω_1 Scorpii ...	<i>B</i> ₂	4.13	240.25	— 20.88	— 0.007	— 0.033	— 2.52	— 11 L		12.0
4094		<i>B</i> ₀	5.79	240.27	— 57.65	— 0.031	— 0.058	+ 1.27	+ 6 L		29.4
4100		<i>A</i>	5.58	240.87	— 33.27	— 0.037	— 0.055				33.6
4115		<i>B</i> ₃	4.70	241.52	— 27.67	— 0.028	— 0.038				36.3
4117	ν »	<i>B</i> ₃	4.29	241.55	— 19.20	— 0.011	— 0.032				19.5
4126		<i>A</i> ₂	5.86	241.90	— 57.65	— 0.014	— 0.056				14.0
4128	θ Normæ....	<i>B</i> ₁	5.36	242.00	— 47.12	— 0.030	— 0.059				26.7
4155		<i>A</i>	4.76	243.65	— 23.92	— 0.014	— 0.040		— 8 L		19.0
4156		<i>A</i> ₅	5.49	243.75	— 49.33	— 0.011	— 0.031	+ 0.21	+ 1 L		19.2
4158	σ Scorpii	<i>B</i> ₁	3.08	243.77	— 25.35	— 0.012	— 0.032	+ 0.00	+ 2.0 orb.		20.9
4178	ρ Ophiuchi...	<i>B</i> ₅	5.22	244.90	— 23.20	— 0.011	— 0.021				27.6
4179		<i>A</i>	5.73	244.95	— 58.37	— 0.021	— 0.053				21.5
4183	χ » ...	<i>B</i> ₃	4.85	245.30	— 18.22	— 0.004	— 0.031				7.9
4198		<i>B</i> ₃	4.87	246.02	— 24.88	— 0.006	— 0.028				11.1
4200		<i>B</i> ₃	4.33	246.20	— 34.48	— 0.009	— 0.024	+ 0.63			15.9
4218	τ Scorpii	<i>B</i> ₀	2.91	247.43	— 28.00	— 0.011	— 0.037	+ 0.32	+ 1.5 L		19.7
4253		<i>B</i> ₀	5.76	249.70	— 58.15	— 0.024	— 0.045				28.0
4277	μ_1 »	<i>B</i> _{3p}	3.09	251.27	— 37.87	— 0.007	— 0.030				13.5
4281	μ_2 »	<i>B</i> ₃	3.64	251.40	— 37.83	— 0.019	— 0.028	+ 0.36	+ 1.7 L		34.4
4321		<i>B</i> ₀	5.06	253.85	— 31.98	— 0.012	— 0.062				10.6
4324		<i>B</i> ₃	5.88	253.97	— 57.37	— 0.015	— 0.029				26.9
4404		<i>B</i> ₃	5.10	259.25	— 44.05	— 0.023	— 0.032				36.1
4426	δ Aræ.....	<i>B</i> ₃	3.79	260.52	— 60.60	— 0.055	— 0.085				26.6
4431	α »	<i>B</i> _{3p}	2.97	261.02	— 49.78	— 0.034	— 0.084	+ 0.47			21.8
4474	κ Scorpii	<i>B</i> ₂	2.51	263.90	— 38.97	— 0.011	— 0.026				22.0
4565	θ Aræ	<i>B</i> ₁	3.90	269.70	— 50.03	— 0.011	+ 0.028	+ 0.59			22.6
4657	α Telescopii .	<i>B</i> ₃	3.76	274.90	— 46.02	— 0.010	— 0.052	— 0.11			11.0

From the galactic coordinates of the stars not bracketed in table XI I have computed the following moments about the medium:—

$$\begin{aligned} \nu_{11} &= +48.865, & \nu_{22} &= +23.457, & \nu_{33} &= +12.242, \\ \nu_{12} &= -6.511, & \nu_{13} &= +10.087, & \nu_{23} &= -0.643, \end{aligned}$$

from which I get the equation:—

$$t^3 - 84.064 t^2 + 1869.129 t - 11045.925 = 0$$

with the roots:—

$$\begin{aligned} t_1 &= +52.425, \\ t_2 &= +22.121, \\ t_3 &= +9.517, \end{aligned}$$

and the dispersion along the axes:—

$$\begin{aligned} \alpha_1 &= 7.241, \\ \alpha_2 &= 4.703, \\ \alpha_3 &= 3.085. \end{aligned}$$

group	q_c	Δq	λ	r	M	w_c	Δw	π_c	$\Delta \pi$	x	y	z
II	28°6	+ 4.8	100.3	23.4	-0.92	-0.70		0.009		+15.6	-15.5	+8.1
II	29.2	- 2.4	105.5	17.0	-0.26	-1.05		0.012		+11.8	-10.0	+7.0
II	27.2	+ 1.2	103.0	24.6	-2.93	-0.47	-0.24	0.008		+15.9	-17.3	+7.2
II	28.0	+ 5.5	99.0	22.1	-3.73	-0.61		0.009		+14.8	-14.7	+7.2
III	27.4	+ 0.5	89.1	18.5	-2.73	+0.06		0.011		+10.9	-14.7	+3.2
III	28.1	+10.3	103.2	19.3	-3.89	-0.90		0.011	0.003	+13.4	-12.0	+7.0
III	26.9	- 9.3	89.2	18.7	-1.39	+0.06	-0.09	0.011		+11.1	-14.7	+3.0
II	27.7	+ 6.4	106.3	25.1	-4.10	-1.10		0.008	0.001	+18.1	-14.6	+9.5
II	27.7	-14.4	106.2	23.1	-1.76	-1.10		0.009	0.000	+16.6	-13.4	+8.8
III	26.4	- 3.8	91.2	20.0	-2.18	-0.08		0.010		+12.3	-15.4	+3.5
	27.2	+ 1.2	103.0	14.8	+0.08	-0.88		0.014		+10.4	- 9.3	+5.0
II	27.4	+15.4	105.7	23.1	-2.70	-1.06	+2.12	0.009		+16.7	-13.6	+8.5
III	27.7	- 1.7	72.4	21.4	-0.86	+1.19	+0.13	0.010		+ 8.8	-19.4	-2.0
III	26.0	- 7.6	94.4	12.2	+0.15	-0.30		0.017		+ 7.9	- 8.9	+2.5
III	25.9	-10.4	99.6	17.0	-1.45	-0.66		0.012		+11.8	-11.3	+4.6
II	26.3	+ 7.3	107.3	22.9	-2.51	-1.17		0.009		+16.9	-13.0	+8.3
III	26.5	+12.5	72.9	13.4	+0.22	+1.15		0.015		+ 5.7	-12.1	-1.4
III	25.4	- 1.3	82.3	12.2	-0.06	+0.53		0.017		+ 6.5	-10.3	+0.3
III	24.9	+ 5.9	103.9	18.5	-1.58	-0.94		0.011		+13.7	-11.4	+5.3
III	24.4	+ 5.2	81.7	24.4	-1.45	+0.57	+1.27	0.009		+12.8	-20.7	-0.4
III	24.7	+ 3.8	102.6	23.1	-3.74	-0.86	+0.05	0.009		+16.9	-14.5	+6.3
III	24.2	- 3.4	105.1	33.0	-2.37	-1.02		0.006		+24.8	-19.7	+9.3
	24.5	+ 3.0	72.9	13.6	+0.12	+1.15		0.015		+ 5.8	-12.1	-1.8
	24.6	+16.7	109.7	24.4	-2.09	-1.32		0.009		+19.0	-12.9	+8.1
III	23.4	+12.3	103.9	27.5	-2.33	-0.94		0.008		+20.7	-16.7	+6.9
III	22.3	+ 6.4	101.4	31.5	-3.16	-0.37	-0.09	0.007		+21.6	-22.5	+4.4
III	22.6	+ 2.9	95.4	20.7	-3.67	-0.78	-0.19	0.010		+15.4	-13.2	+4.1
	21.1	- 6.9	74.0	15.3	-0.16	+1.08		0.014		+ 7.0	-13.4	-2.5
III	19.3	+ 5.8	93.5	26.3	-4.01	-0.24		0.008		+18.2	-18.9	+1.2
III	19.2	-15.2	86.1	23.9	-3.24	+0.27	+0.32	0.009		+16.6	-17.2	+1.1
III	17.8	+ 7.2	99.6	12.6	-0.45	-0.66		0.016		+ 9.6	- 8.1	+1.0
	18.0	- 8.9	75.3	24.0	-1.03	+1.00		0.009		+10.4	-21.5	-2.8
	13.8	-22.3	90.0	20.6	-1.47	+0.00		0.010		+13.8	-15.1	-2.1
	13.5	-13.1	73.4	7.7	-0.64	+1.12		0.027		+ 3.6	- 6.5	-2.0
	12.6	- 9.2	84.0	8.9	-1.78	+0.41	+0.85	0.023		+ 5.4	- 6.9	-1.5
	10.7	-11.3	94.9	28.9	-4.77	-0.34		0.007		+21.4	-18.8	-3.0
	6.6	-15.4	84.6	26.8	-3.24	+0.37	+0.69	0.008		+16.9	-19.6	-6.9
	2.9	- 8.1	89.0	15.3	-2.16	+0.07	+1.09	0.014		+10.6	-10.2	-4.3

The directions of the principal axes are then:—

$$\begin{aligned} L_1 &= 347^\circ_0, & L_2 &= 259^\circ_1, & L_3 &= 16^\circ_7, \\ B_1 &= +13^\circ_9, & B_2 &= -7^\circ_3, & B_3 &= -74^\circ_0, \end{aligned}$$

and the density:—

$$C = 0.0889 \text{ stars pro cubic sirrometer.}$$

From this we get the frequency-function:—

$$F = 0.089 \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{52.43} + \frac{y_1^2}{22.12} + \frac{z_1^2}{9.52} \right)}.$$

The cluster's motion is nearly parallel to the Milky Way and nearly in the direction of the longest axis.

Dividing the stars into three groups, the first containing 29 stars with a mean distance from the sun of $\bar{r} = 15.5$ sir. and a mean angular distance from the convergent of

$\bar{\lambda} = 95^\circ$, the second with 44 stars, $\bar{r} = 17.3$ sir., $\bar{\lambda} = 75^\circ$, the third with 25 stars, $\bar{r} = 22.6$ sir., $\bar{\lambda} = 55^\circ$, I found for the three groups three different points of convergence, namely:—

- (1) $A = 87^\circ$, $D = -40^\circ$,
- (2) $A = 105^\circ$, $D = -41^\circ$,
- (3) $A = 111^\circ$, $D = -54^\circ$,

or for the groups (1) and (3) corrected for solar motion and transformed into galactic coordinates:—

- (1) $L_0 = 332^\circ$, $B_0 = -15^\circ$,
- (2) $L_0 = 312^\circ$, $B_0 = +13^\circ$.

This matter of fact will indicate either a curvature in the motion or that the cluster is composed of three or more smaller clusters.

I will assume the motion exactly in the galactic plane with the sun placed in this plane. The angle at the sun between the first and third group is 40° . Assuming the orbit of the star group to be a cercle, the angle between the radius from the centre to the first and second group will be about 20° . I then conclude that the centre of this cercle lies on the periphery of the cercle through the group with the sun as centrum. The distance from the sun to the centrum of the orbit will then be about 18 sir. The direction of the absolute motion is (approximatively) away from the sun, from which I conclude that the centrum is situated about 90° from the absolute convergent. The radius in the assumed circular orbit will then be about 25 siriometers and the time of rotation about 130 stellar-years.

CHAPTER VIII.

A. THE 61-CYGNI-CLUSTER.

For 12 stars, scattered over the whole sky, with large proper motions in the same direction, a convergent was fixed by B. BOSS¹⁵ by means of the method of ARGELANDER:—

$$A = 99^{\circ}9', \quad D = +0^{\circ}5,$$

and from the radial-velocities of six stars (61 Cygni from the YERKES' observations and the others from LICK) the stream-velocity was calculated to be:—

$$\Omega = 95 \text{ km./sec.}$$

Freed from the solar motion the position will be:—

$$\begin{aligned} A_0 &= 100^{\circ}56', \quad D_0 = +9^{\circ}20', \quad \Omega = 80.5 \text{ km./sec,} \\ L_0 &= 173^{\circ}, \quad B_0 = +5^{\circ}5. \end{aligned}$$

The disagreement between observed and calculated radial-velocities for Boss 372 and between the observed and computed parallaxes (Groningen, Publ. 24) of Boss 127, 372, 927 was already here observed. Assuming the real existence of this group, BOSS explains the greater deviations in position-angle in comparison with the Taurus-cluster in several different ways. The stars, being of a later spectral-type (*F-G* 5), have lived a longer time, and therefore the chance of perturbations has been greater than for the *A*-stars in the Taurus-cluster and Ursa major-cluster. The stars, which are more scattered in the sky, will be more affected by systematic errors in the proper motions, which, however, is partly eliminated by the fact that the motions are larger. Supposing the force which causes the preferential motion of the stars to be an electromagnetic force with great distances between the poles, the influence of the curvature of the lines of force will be rather small for a more closed group, but will be appreciable in a slight divergence from the parallelism in a group of stars more widely scattered.

In a later paper BOSS¹⁶ augments the group by 7 new members whose radial-velocities are known and agree rather well. The parallax has been observed for three stars and shows for two of them a discrepancy between observation and calculation which seems to exclude them from the cluster. In table III in the same paper he gives a list of 38 stars with proper motions $> 20''$ pro century, among which he suspects members of the group. In table IV he gives a list of 13 stars, which converge towards the convergent of the 61-Cygni-cluster, but with a stream-velocity more agreeing with the Taurus-cluster.

RUSSELL¹⁰³ suggests 12 new members with known parallaxes, but in a later¹⁰⁴ paper he proposes the two stars Boss 372, 514 as members of the Hyades.

In his Stellar motions I-V PLUMMER⁹¹⁻⁹⁵ points out twelve stars of the earlier spectral types with unusually large proper motions, which may perhaps belong to the 61-Cygni-cluster.

TABLE XII.
THE 61-CYGNI-CLUSTER.

A. ONE CLUSTER TOWARDS $A = 99^{\circ}1$; $D = +0^{\circ}5$.

P.G.C.	Sp.	m	α (1875)	δ (1875)	μ	π_c	π_0	w_c (km.)	w_0 (km.)	Δq	x	y	z
3	F	6.10	359.9	+ 57.7	0.267	0.014	{ 0.102 A, Ye, Y, D [0.08]	— 7.4		— 0.2	+ 1.3	+ 14.9	— 1.3
4	G	5.77	0.0	— 49.8	0.534	0.025		— 10.4		+ 1.9	+ 0.8	— 3.0	— 7.4
86	F	6.35	5.7	+ 76.3	0.336	0.018	[0.032]	— 0.6		— 6.5	+ 0.2	+ 10.7	+ 2.7
127	K	5.71	7.7	— 25.5	1.386	0.065	{ 0.104 M, F [0.066]	— 2.5	+ 16.8 L, W	— 0.2	+ 0.2	+ 0.2	— 3.0
314	A ₅	3.80	19.4	+ 59.6	0.308	0.015	0.029 Ky	+ 9.3	+ 9 L	— 0.2	— 1.2	+ 14.0	— 0.5
372	F	5.10	23.6	+ 42.0	0.819	0.045	{ 0.098 A, M, Y, J [0.037]	+ 18.1	+ 5.0 L, B	— 0.5	— 0.9	+ 4.6	— 1.7
377	G ₅	6.03	23.9	— 56.8	0.285	0.015		+ 12.4		+ 2.2	— 1.8	— 7.2	— 11.8
514	G	5.07	32.4	+ 33.7	1.179	0.064	{ 0.101 A, M, Y [0.063]	+ 31.6	— 3.4 C.C.	+ 0.9	— 0.9	+ 2.6	— 1.8
667	F	5.85	42.7	+ 20.2	0.224	0.014	[0.032]	+ 49.6		+ 4.0	— 7.5	+ 10.5	— 8.1
927	—	—	58.7	+ 35.0	2.208	0.145	{ 0.040 Ye, S, Y [0.032]	+ 59.7		— 4.2	— 1.2	+ 1.5	— 0.4
948	A ₅	5.57	60.1	— 28.0	0.224	0.016		+ 64.8		— 3.4	— 8.0	— 2.1	— 9.4
1259	G	4.85	77.6	+ 40.0	0.842	0.048	{ 0.081 A, M, S [0.079]	+ 70.4	+ 65.4 L, B	+ 5.9	— 2.1	+ 2.1	+ 0.2
1400	K	5.06	84.2	— 76.4	0.316	0.017		+ 20.9	+ 60.1 orb.	— 1.8	— 2.5	— 9.8	— 6.4
1449	G ₅	5.65	86.8	— 80.6	1.095	0.059		+ 14.0	+ 12.2 L	+ 1.6	— 0.5	— 2.6	— 1.5
1767	F	5.05	101.6	— 46.5	0.357	0.024		+ 64.8		— 1.3	— 6.1	— 5.9	— 2.8
1823	K ₅	5.08	105.0	— 67.8	0.244	0.013		+ 35.2	+ 41 L	+ 2.0	— 4.0	— 15.2	— 3.8
1857	K ₂	5.11	106.8	— 48.7	0.197	0.013		+ 61.4	+ 64.8 L	— 4.3	— 10.4	— 11.2	— 4.5
1972	K ₅	3.27	111.3	— 43.1	0.191	0.014		+ 67.3	+ 87.3 orb.	+ 0.9	— 10.8	— 10.1	— 2.9
2161	—	—	120.9	+ 32.9	0.807	0.066	{ 0.046 M, Y, Jo [0.058]	+ 74.6	+ 27 W	+ 2.3	— 2.8	+ 1.0	+ 1.6
2427	F	5.17	134.1	— 58.9	0.826	0.018		+ 39.8	+ 7 L	— 5.2	— 1.2	— 12.0	— 0.6
2563	F ₂	5.44	142.1	— 80.3	0.194	0.011		+ 10.9		+ 5.9	— 2.1	— 17.5	— 6.8
2657	K	5.00	147.1	— 25.4	0.211	0.013		+ 57.1	+ 53.1 L	+ 5.7	— 10.4	— 11.6	+ 3.8
2717	—	—	151.9	— 6.8	0.188	0.012		+ 57.0		— 1.9	— 8.8	— 10.5	+ 10.5
2803	F	5.08	156.6	— 53.1	0.442	0.023		+ 30.0		+ 2.8	— 8.4	— 3.2	+ 0.8
2943	—	—	164.6	+ 25.9	0.406	0.022	{ 0.039 Y [0.028]	+ 35.8	— 9 W	+ 0.5	— 3.5	+ 0.0	+ 8.3
3095	G	5.04	175.2	— 59.8	1.574	0.081		+ 17.2	+ 17.5 L, C	— 4.7	— 0.5	— 2.3	+ 0.9
3292	A ₃	4.02	187.7	— 47.6	0.196	0.009		+ 1.1		+ 6.1	— 4.4	— 21.3	+ 5.5
3353	G	6.15	191.7	— 2.9	0.259	0.014	[0.026]	— 4.3		+ 2.8	+ 0.6	— 8.0	+ 12.8
3383	K	2.95	194.0	+ 11.6	0.270	0.015	{ 0.034 F [0.025]	— 7.7	— 13.6 m, L, B, C	— 2.6	+ 0.8	— 3.8	+ 13.4
3385	F	6.02	194.7	+ 64.3	0.176	0.011		— 2.9		— 3.7	+ 0.9	+ 10.2	+ 15.4
3785	F	5.98	221.0	+ 38.3	0.273	0.016	{ 0.010 A [0.019]	— 38.9		— 1.8	+ 4.7	+ 2.9	+ 11.6
3795	K	5.50	221.5	+ 37.8	0.228	0.013		— 39.5		— 0.8	+ 6.6	+ 3.7	+ 14.1
3869	G	6.43	226.5	— 24.8	0.399	0.024		— 52.7		— 6.4	+ 4.9	— 6.5	+ 4.0
3940	F _p	3.70	230.7	+ 29.5	0.187	0.012	[0.016]	— 54.4	— 21.3 orb.	— 0.3	+ 4.1	+ 0.8	+ 5.7
4246	G	3.00	249.1	+ 31.4	0.601	0.045	{ 0.125 A, Ye, S, R, Sm [0.046]	— 69.5	— 71.5 "	+ 2.7	+ 3.7	+ 1.8	+ 3.2
4511	A	5.19	267.5	+ 50.8	0.207	0.013		— 57.9		— 3.2	+ 9.6	+ 10.4	+ 7.5
4568	K	3.07	269.4	— 30.4	0.202	0.020		— 81.2	+ 22.1 "	+ 2.5	+ 8.5	— 5.3	— 0.9
4570	F ₃	5.92	269.2	— 73.7	0.229	0.012		— 27.0		— 6.1	+ 4.6	— 13.9	— 6.6
4950	G ₅	5.23	289.8	+ 11.7	0.961	0.165	{ 0.067 A, M, Ye [0.095]	— 91.3	— 97.6 W	— 7.7	+ 1.3	+ 0.3	— 0.1
4953	F	3.48	289.8	+ 2.9	0.267	0.065	{ 0.067 A, M, Ye [0.048]	— 93.2	— 19 orb.	— 1.1	+ 2.9	+ 0.4	— 0.4
5032	A	5.50	294.1	— 15.8	0.233	0.032		— 88.6		— 5.7	+ 5.6	— 0.9	— 1.9
5336	K	2.64	310.4	+ 33.5	0.485	0.034	{ 0.036 A, M, F, J [0.044]	— 67.4		— 1.5	+ 4.3	+ 5.1	— 0.6

P.G.C.	Sp.	<i>m</i>	α (1875)	δ (1875)	μ	π_c	π_0	w_c (km.)	w_0 (km.)	Δq	<i>x</i>	<i>y</i>	<i>z</i>
5365	<i>A</i> ₈	5.07	311 [°] 4	+ 43 [°] 6	0 ^{''} 180	0 ^{''} 011	0.029 A	— 57.6		— 3.2	+ 11.8	+ 15.0	+ 0.0
5433	<i>K</i> ₅	5.57	315.8	+ 38.1	5.252	0.342	{ 0.347 A, M, W [0.325]	— 59.8	{ — 64.0 L, W	— 2.6	+ 0.4	+ 0.5	— 0.1
5434	<i>K</i> ₅	6.28	315.8	+ 38.1	5.153	0.335		— 59.8		— 4.2	+ 0.4	+ 0.5	— 0.1
5446	<i>F</i> ₅	5.26	316.8	— 39.9	0.282	0.015		— 52.9		+ 6.8	+ 8.1	— 4.7	— 9.2
5559	—	—	323.4	— 0.6	0.239	0.017	{ 0.017 F, J [0.021]	— 68.2	— 17 W	+ 3.0	+ 9.0	+ 3.6	— 7.1
5654	<i>K</i> ₅	4.74	328.4	— 57.3	4.695	0.253	0.28 V	— 34.2	— 38.7 L	+ 2.0	+ 0.4	+ 0.3	— 0.6
5703	<i>A</i>	3.70	330.9	+ 5.9	0.279	0.018	—	— 58.4		+ 1.6	+ 7.0	+ 5.3	— 6.6
5721	<i>F</i> ₈	5.42	331.8	+ 56.2	0.272	0.014	{ 0.027 A [0.040]	— 31.4		— 5.3	+ 5.4	+ 14.0	+ 0.0
5758	<i>F</i>	5.42	333.5	— 72.9	1.451	0.070	0.03 V	— 17.7	+ 25.6 L	+ 5.6	+ 0.5	— 2.1	— 2.0
5786	<i>F</i>	5.85	335.1	+ 3.8	0.298	0.018	{ 0.067 F, J [0.042]	— 53.1		+ 4.8	+ 6.4	+ 5.0	— 7.5
5894	<i>F</i>	5.30	336.5	+ 9.2	0.519	0.031	{ 0.042 Ye, Y, F [0.038]	— 50.4	+ 13.4 L	— 1.9	+ 5.8	+ 5.8	— 7.4
5917	<i>K</i>	5.59	342.8	+ 20.1	0.218	0.012	[0.063]	— 39.3		+ 3.1	+ 7.3	+ 11.9	— 9.7
5977	—	—	346.9	— 9.6	0.560	0.030	{ 0.019 Y [0.015]	— 35.6		— 1.5	+ 2.7	+ 2.0	— 6.2
6020	<i>F</i> ₂	6.53	349.4	+ 31.9	0.287	0.012	[0.014]	— 26.8		— 1.2	+ 5.6	+ 15.3	— 7.7
6129	<i>K</i>	6.55	356.6	+ 74.9	0.333	0.017	{ 0.097 A, M, W [0.105]	— 4.7		— 3.6	+ 0.6	+ 11.6	+ 2.9

B. THREE CLUSTERS.

P.G.C.	Star-name	Sp.	<i>m</i>	π_c	π_0	w_c	w_0
<i>Cluster I. The F-type stars.</i>							
372	Pi. 142	<i>F</i> ₈	5.1	0 ^{''} 070	0.092	+ 10.8	+ 5.0 L, B
631	Br. 390	<i>F</i> ₅	4.6	0.032	{ 0.084 M [0.063]	+ 27.1	+ 25.5 L
3558	ϵ Bootis	<i>F</i> ₆	4.5	0.043	{ 0.046 A, Y [0.050]	— 14.8	— 16.2 L, B
4570	Lal. 7507	<i>F</i> ₅	5.9	0.020		— 16.1	
	Gr. 3357	<i>F</i> ₇	6.6	0.036	{ 0.040 Ye, J 0.039	— 35.3	— 37 W
5446	Lal. 8719	<i>F</i> ₅	5.4	0.023		— 31.4	
<i>Cluster II. The G-type stars.</i>							
	Lal. 2450	<i>G</i> ₀	8.1	0 ^{''} 033	{ 0.017 Y [0.022]	+ 13.9	0.0 W
1449	π Mensæ	<i>G</i> ₅	5.7	0.064		+ 12.2	+ 12.2 L
2943	51 Leo minor . . .	<i>F</i> ₅	7.5	0.025	0.033	+ 34.1	— 9 W
3095	66 G. Cent.	<i>G</i>	5.0	0.092		+ 14.9	+ 17.5 L, C
3869	Pi. 15 ^b 5	<i>G</i>	7.3	0.028		— 45.8	
	Pi. 23 ^b 267	<i>G</i> ₀	6.2	0.045	{ 0.033 A, Y [0.042]	— 10.9	
<i>Cluster III. The K-type stars.</i>							
	Lal. 39866	<i>K</i> ₅	8.4	0 ^{''} 078	{ 0.061 A, Ye, Y [0.033]	— 89.2	
5433	{ 61 Cygni	<i>K</i> ₅	5.6	{ 0.312	{ 0.316	{ — 64.8	— 64.0 W, L
5434		<i>K</i> ₅	6.3				
5654		<i>K</i> ₅	4.7				
	ϵ Indi	<i>K</i> ₅	4.7	0.231	0.284	— 37.1	— 38.7 L

The new radial-velocities and parallaxes determined in the last ten years show still more discrepancies in comparison with the calculated quantities under the assumption of the reality of the 61-Cygni-group.

CORLIN³² has made a new investigation of 41 stars in the cluster with known radial-velocities and spectroscopic parallaxes. For each star he has calculated the absolute velocity towards the convergent. 14 stars are excluded which show too great disagreement between the velocity from radial-velocity and that from spectroscopic parallax, or which, because of reversed sign of the radial-velocity, are proved not to go towards the convergency-point, or which lie about 90° from the convergent. The remaining 27 stars are separated into three distinct groups with well marked velocities and spectral-types:—

The *F*-star cluster, containing 4 stars (later augmented to 6 stars) with the mean velocity 56.5 km./sec. and the mean absolute magnitude $+3^m_0$.

The *G*-star cluster, containing 4 stars (5) with the velocity 82.5 km./sec. and the mean absolute magnitude $+4^m_9$.

The *K*-star cluster, containing 3 stars (4) with the velocity 103.0 km./sec. and the mean absolute magnitude $+7^m_4 (+5^m_8)$.

With BOSS's apparent convergent (1900) the true convergents corrected for solar motion will be:—

$$\begin{array}{llll} F\text{-star cluster} & \dots\dots A_0 = 6^h 53^m, & D_0 = +14^\circ, & \varrho_0 = 43 \text{ km./sec.}, \\ G\text{-} & \text{»} & \dots\dots A_0 = 6^h 47^m, & D_0 = +9^\circ, \quad \varrho_0 = 66 \text{ »}, \\ K\text{-} & \text{»} & \dots\dots A_0 = 6^h 45^m, & D_0 = +7^\circ, \quad \varrho_0 = 86 \text{ »}. \end{array}$$

The discrepancies in parallax and radial-velocities are shown in table XII B taken from the memoir of CORLIN, but completed with several later observations from ADAMS and JOYS:—"The parallaxes of 1646 stars", and VOÛTE:—"First catalogue of radial-velocities". The differences between observed and calculated quantities then seem to be rather great for several stars also in these very small groups, of which the cluster III ("the 61-Cygni-cluster") contains only three stars.

In table XII A I have collected the parallaxes and radial-velocities of the stars in BOSS' tables I-III, computed by means of the convergent and velocity of BOSS, and the observed quantities from different sources. The great discrepancies for a great part of the stars between calculated and observed quantities are plain enough. With the equations (4) the poles of the proper-motion-circles of the individual stars are computed, (fig. X) which are arranged, as was to be supposed, on a great circle over the sphere. I have then constructed for every star the direction in the neighbourhood of the convergent of the proper motion in order to calculate the distance from the convergent to the remotest proper-motion-circles and then compute the quotient of DZIEWULSKI:—

$\frac{n}{N} : \frac{w}{4\pi} = Q$. In groups I-II of BOSS with 19 stars, two stars have a distance of about 6 degrees from the convergent to the direction of motion, and in groups I-III with 57 stars there are three stars with a distance of about 7 degrees.

The mean velocity-ellipsoid for the stars of spectral-types *F*, *G* and *K* has the following relation:—

$$\frac{\alpha_2 + \alpha_3}{2\alpha_1} = 0.3 \text{ (mean value)}$$

between the axes according to CHARLIER and GYLLENBERG.

Instead of the relation $\frac{\omega}{4\pi}$ I then take the relation between the sector thus limited and the whole ellipsoid, taking into consideration the position of the convergent relative to the vertex of preferential motion, and as N I take 1924, which is the number of stars with proper motions $> 0''.20$ according to DYSON³⁸. The quotients then are for groups I-II:— $Q = 1.0$, and for groups I-III:— $Q = 2.5$. But, according to DYSON, the star-streaming is shown more prominently, when we leave out the smaller motions, and the quotients then ought to be further diminished. It is also to be noted that eight stars in the table have p.m. $< 0''.20$. There seems, then, to be no strong reason left that the apparent common motion of several stars of large proper motions should be due to the existence of one or three moving clusters.

Nevertheless I have conversed the equatorial coordinates into galactic coordinates with help of the plate I in "Introduction to stellar statistics" by C. V. L. CHARLIER (1921), and computed the coordinates in space x, y, z . I then get the moments around the medium:—

$$\begin{aligned} \nu_{11} &= 28.40, & \nu_{22} &= 75.00, & \nu_{33} &= 40.20, \\ \nu_{12} &= 18.84, & \nu_{13} &= 0.25, & \nu_{23} &= 1.98, \end{aligned}$$

and the equation:—

$$t^3 - 143.60 t^2 + 5927.76 t - 71258.44 = 0,$$

which has the roots:—

$$t_1 = 40.22, \quad t_2 = 81.23, \quad t_3 = 22.06.$$

The dispersion along the three principal axes are then:—

$$\alpha_1 = 6.3, \quad \alpha_2 = 9.0, \quad \alpha_3 = 4.7;$$

and the direction of these axes:—

$$\begin{aligned} L_1 &= 169^\circ.2, & L_2 &= 72^\circ.0, & L_3 &= 340^\circ.4, \\ B_1 &= +80^\circ.6, & B_2 &= +2^\circ.7, & B_3 &= +1^\circ.4. \end{aligned}$$

The density is:—

$$C = 0.013,$$

and the frequency-function:—

$$F = 0.013 \cdot e^{-\frac{1}{2} \left(\frac{x_1^2}{40.2} + \frac{y_1^2}{81.2} + \frac{z_1^2}{22.1} \right)}.$$

The cluster is travelling nearly in the direction of the shortest of the axes.

B. THE MONOCEROS-CLUSTER.

From the catalogue of ADAMS and JOY³ five stars are separated out by CORLIN³², which show community in spectral-type, magnitude and proper motion. From the proper motion and the radial-velocity of one star (Bradley 3077) he calculates the convergent and the stream-velocity

$$\begin{aligned} A &= 6^{\text{h}}13^{\text{m}} \pm 4^{\text{m}}, \\ D &= -12^{\circ}.5 \pm 0^{\circ}.6, \\ \Omega &= 62 \text{ km./sec.} \end{aligned}$$

The absolute convergent is $A_0 = 6^{\text{h}}18^{\text{m}}$, $D_0 = -4^{\circ}.5$, $\Omega_0 = 43.5 \text{ km./sec.}$

His search for new members in different catalogues gave the result that among 254 stars converging towards this point there are only twelve stars with known spectroscopic parallaxes whose computed velocity designs them as belonging to the group. The spectral-types for ten of these stars vary from $K0$ to $K5$, while the other two have the types M and F and are excluded by the author. The apparent magnitudes of the remaining stars vary from $5^{\text{m}}.6$ to $8^{\text{m}}.8$, and the absolute magnitudes from $5^{\text{m}}.9$ to $7^{\text{m}}.8$ ($M_0 = +6^{\text{m}}.72$). The velocities computed from the parallaxes differ from the velocity of Bradley 3077 (62 km.) computed from the radial-velocity of this star, by about 10 km. As possible members of the stream 25 faint stars ($5^{\text{m}}.9$ to $7^{\text{m}}.8$) are pointed out, five of which have known spectral-type $K0$ - $K7$ and the others known spectroscopic parallax.

The very good convergence and the close connection between the magnitudes and the spectral-types of the adopted stars are very sensational, but the position of the convergent in the neighbourhood of the vertex of KAPTEYN, the lack of observed radial-velocities and the small number of the members will raise some doubt as to the real existence of the cluster.

An investigation into the position in space of the Monoceros-cluster has been made by TURNER¹¹⁹. He found that the 12 stars (with the exception of two of the "safe" stars) form a flat cluster, travelling nearly in its plane, the inclination between the direction and the plane being 6° . The 25 suspected stars he divided into two flat clusters, with the inclinations 38° and 47° between the direction and the plane.

TABLE XIII.
THE MONOCEROS-STREAM.

Star-name	Sp.	m	α	δ	w_c (km./sec.)	w_0	π_c	π_0
Lal. 2682...	K_3	5.9	$20^{\circ}90$	$+21^{\circ}22$	$+12.8$		$0''.041$	$[0.050]$ 0.067 Y, D
» 3987...	K_2	5.9	31.88	$+67.22$	-1.1		0.048	$[0.046]$ 0.071 S, Y
Mün. 5178...	K_5	7.7	154.92	-0.97	$+30.1$		0.061	$[0.050]$
Lal. 24774...	K_0	6.1	199.02	$+43.63$	-21.3		0.036	$[0.038]$ 0.179 Y
» 27026...	K_5	7.4	221.50	-23.88	-29.1		0.088	$[0.072]$ 0.041 F
» 29330...	K_0	7.8	240.80	$+10.95$	-52.7		0.071	$[0.032]$
» 45292...	K_5	6.6	346.00	-2.80	-17.4		0.047	$[0.044]$ 0.085 Y
Br. 3077....	K_5	6.7	347.12	$+56.62$	-20.6	-20.4 W	0.167	$[0.209]$ 0.172 S, J, P, F
Lal. 45638...	K_2	6.3	348.45	$+4.87$	-16.7		0.041	$[0.030]$ 0.011 M, Ye, Y, J
W.B. 23 ^b 257	K_1	6.8	348.75	$+28.82$	-19.8		0.046	$[0.030]$ 0.061 Ye

C. STROOBANT'S CLUSTER.

Seven stars, namely α Cassiopeiae, β Persei, α Persei, α Scorpii, γ Cygni, ϵ Pegasi, α Pegasi, with remarkable small proper motions and radial-velocities and known parallaxes are suggested by STROOBANT¹¹⁴ to form a moving cluster with the sun as the eighth member of the system. The absolute velocities of the stars are computed and show rather large variations, from 11.3 to 22.1 km./sec., when the sun's velocity is assumed to be 19.4 km./sec. The computed directions in space are parallel with the sun's within a range of about six degrees.

With the method I I have computed the convergent of the cluster to be:—

$$A = 271^{\circ}6, \quad D = +42^{\circ}1, \quad \Omega = 0.37 \text{ sir./st.}$$

The great discrepancies in the position-angles for several stars and between the computed and observed parallaxes, shown in the table, will raise very great doubt as to the real existence of this cluster.

TABLE XIV.

STROOBANT'S CLUSTER.

$$A = 291^{\circ}6; \quad D = +42^{\circ}1; \quad \Omega = 0.37 \text{ sir./st.}$$

P.G.C.	Star-name	Sp.	<i>m</i>	α	δ	<i>u</i>	<i>v</i>	<i>w</i> (km.)	π	<i>q</i> ₀	<i>q</i> _c	λ	<i>r</i>	π_c
135	α Cassiop....	<i>K</i>	2.47	8°10	+55°98	+0.053	—0.031	—3 L, m, W	{ 0''.023 M, F [0.020]	121°	121°	59.2	1.1	0''.187
708	β Persei.....	<i>B_s</i>	var.	45.43	+40.57	+0.007	—0.005	+5 orb.	0.030	125°	148	87.4	8.5	0.024
772	α "	<i>F₅</i>	1.90	49.30	+49.50	+0.028	—0.028	—2.4	{ 0.017 Ye, M, F [0.023]	136°	150	81.2	2.0	0.103
4193	α Scorpii....	<i>M_{ap}</i>	1.22	245.83	—26.20	+0.007	—0.033	—3.1 orb.	{ 0.029 G [0.017]	192°	160	72.3	2.1	0.098
5229	γ Cygni.....	<i>F_{8p}</i>	2.32	304.65	+39.93	+0.001	—0.003	—5.6 P, m, L, B	{ 0.014 A, M, Y, F [0.009]	162	112	42.1	17.0	0.012
5584	ϵ Pegasi....	<i>K</i>	2.54	324.83	+9.40	+0.025	—0.001	+5.3 m, L, p, Y, L, B, C	{ 0.006 A, M, F [0.028]	92	135	56.8	2.5	0.082
5944	α "	<i>A</i>	2.57	345.0	+14.67	+0.058	—0.045	+2.0	0.036 F	127	130	68.0	0.9	0.229

CHAPTER IX.

A. THE α -LYRÆ-CLUSTER.

A system of stars with parallel motion is formed by the stars α Lyræ, τ Coronæ and ϵ Cephei. The system has been investigated by DZIEWULSKI⁴⁰, and the convergent determined by him by means of the method of HÖFFLER was found to be:—

$$A = 68^{\circ}.8, \quad D = +6^{\circ}.0, \quad \Omega = 19.8 \text{ km./sec.},$$

or corrected for the solar motion:—

$$A_0 = 7^{\circ}.9, \quad D = +58^{\circ}.0, \quad \Omega_0 = 13.7 \text{ km./sec.}, \\ L_0 = 88^{\circ}, \quad B_0 = -4^{\circ}.$$

He augments the group by the Bradley-stars (Groningen Publ. 9):—32 Ursæ majoris, θ Crateris, γ Corvi, α Comæ Berenice, Br. 2792. All these stars have known radial-velocities and most of them have known parallaxes.

From the 6 stars of spectral-type *B8-A5* we get the mean absolute magnitude

$$M_0 = +0^m_{56}.$$

In fig. XI the star-places are given in rectangular galactic coordinates. There is some indication of flatness in the structure.

TABLE XV.

THE α -LYRÆ-CLUSTER.

$$A = 68^{\circ}.8; D = +6^{\circ}.0; \Omega = 19.8 \text{ km./sec.}$$

P.G.C.	Star-name	Sp.	<i>m</i>	α	δ	w_c (km./sec.)	w_0	π_e	π_0	M_0	<i>x</i>	<i>y</i>	<i>z</i>
2726	32 Ursa maj.	<i>A</i> ₃	5.74	152°70	+ 65°60	+ 2.7	— 1.8 W	0''.022	—	+ 0.86	—2.6	+ 6.1	+ 6.6
3055	θ Crateris . .	<i>B</i> ₉	4.81	172.90	— 9.25	— 5.1	— 8.0 W	0.015	—	—0.88	—4.3	—7.7	+10.5
3191	γ Corvi	<i>B</i> ₃	2.78	182.68	—16.98	— 8.2	— 7	0.042	—	—0.66	—6.0	—3.4	+ 3.5
3412	α Comæ Ber.	<i>F</i> ₅	4.47	196.28	+ 18.05	—10.8	—16.8	0.128	0.067 F, Sl, M [0.055]	+ 3.43	+ 0.1	—0.2	+ 1.6
4108	τ Coronæ . . .	<i>G</i> ₂	4.94	241.38	+ 36.75	—14.4	—12.8 L	0.113	0.044 A [0.038]	+ 3.64	+ 1.0	+ 0.5	+ 1.3
4722	α Lyræ	<i>A</i>	0.14	278.40	+ 38.68	—12.1	—13.8 L	0.104	0.094 G	—1.36	+ 1.6	+ 1.0	+ 0.6
5511	Br. 2792 . . .	<i>A</i> ₂	5.54	320.42	+ 46.28	— 2.8	+ 1. W	0.052	0.084 G	+ 2.55	+ 2.1	+ 3.3	— 0.8
5742	ϵ Cephei	<i>A</i> ₅	4.23	332.85	+ 56.55	+ 0.6	— 0.2 L	0.108	0.054 G, Sl, M, A, Mc	+ 2.77	+ 0.7	+ 1.8	+ 0.0

B. THE ORION-CLUSTER.

Several stars in the environs of the great Orion-nebula ($\alpha = 5^h 13^m - 5^h 40^m$, $\delta = +7^{\circ}$ to -14°) seem to show a common motion. The proper motions are very small, but the radial-velocities show a remarkable conformity. It is possible that the nebula partakes

in the common motion of the stars. The stars also show great conformity in the spectral-types. In fact, out of 25 stars 23 are of the spectral-type *Oe5-B3*, only 1 *B5*-star and 1 *B8*-star. The group is examined by KAPTEYN⁶⁶ in his great investigation into the parallaxes of the *B*-stars. (The Nebula-group.) He found for the group that the convergent lies within 13 degrees from:— $A = 5^h 25^m$, $D = -1^\circ 4$ (the mean radial-velocity:— $W = +22.7$ km./sec.). The mean parallax of the outside stars in the region of Orion (the “Nebula-group” excluded) he determined by the luminosity law to be

$$\pi = 0''.0081,$$

when he assumes that the stars form a stream towards the point:—

$$A = 86^\circ, \quad D = -11^\circ.$$

Attributing the difference between the estimated mean apparent magnitudes for the Nebula-group and for the surrounding stars to the difference in distance of the two groups he found for the Nebula-group the mean parallax:—

$$\pi = 0''.0054.$$

His group consists of bright *B*-stars, between the limits:— $\alpha = 5^h 20^m$ - $5^h 40^m$, $\delta = +2^\circ$ to -7° augmented by faint *B*- and *A*-stars from the Draper-catalogue.

From the great positive radial-velocities of the group and the small apparent motions we can conclude that the group is moving from the sun. This will cause an apparent change in the diameter of the cluster, from which the mean parallax can be computed. BERGSTRAND⁸ has from the mean radial-velocities of 18 stars (17 *B*-stars and the star 1366, δ Orionis of the type *Oe5*), $\bar{w} = +21.4$ km., and from the yearly change in the diameter (assuming δ Orionis to be placed in the centre of the group) computed the mean parallax to be:—

$$\pi = 0''.008.$$

I have with the first 17 stars in the table computed the mean values of the coordinates:— $\bar{\alpha} = 80^\circ 1$, $\bar{\delta} = -1^\circ 4$, and the proper motions, radial-velocities and parallaxes:— $\bar{\mu} = 0''.005$, $\bar{w} = 4.61 - 0.91 = 3.7$ sir./st., $\bar{\pi} = 0''.0055$, from which by means of the equations (2) and (3) in chapter I we get the stream-velocity:—

$$\Omega = 3.86 \text{ sir./st.},$$

and the convergent:—

$$A = 78^\circ 4, \quad D = -17^\circ 5.$$

From the mean apparent magnitude $\bar{m} = 3.91$ we then have the mean absolute magnitude of the 17 brightest stars in the group:—

$$M_0 = -3^m 96.$$

Corrected for the solar motion the convergent will be:—

$$A_0 = 355^\circ 7, \quad D_0 = +51^\circ 4, \quad \Omega_0 = 5.6 \text{ km./sec.},$$

or in galactic coordinates:—

$$L_0 = 80^\circ, \quad B_0 = -9^\circ.$$

The equations (2) and (3) have here the form:—

$$\begin{aligned} -0.048 \alpha + 0.002 \beta - 0.024 \gamma &= 0, \\ +0.171 \alpha + 0.985 \beta - 0.024 \gamma &= 0.959, \\ \alpha^2 + \beta^2 + \gamma^2 &= 1. \end{aligned}$$

TABLE XVI.

THE ORION-CLUSTER.

$$A = 78^\circ 4; \quad D = -17^\circ 9; \quad \Omega = 3.9 \text{ sir./st.}$$

P.G.C.	Star-name	Sp.	<i>m</i>	α	δ	<i>u</i>	<i>v</i>	<i>w</i> (sir.)	π
1147	π_4 Orionis	B_3	3.78	71° 47	+ 5° 43	— 0".005	— 0".006	+ 4.92	0.003 G
1159	π_5 "	B_3	3.87	72.25	+ 2 27	— 0.003	— 0.003	+ 3.80	
1262	τ "	B_5	3.68	78.20	— 6.95	— 0.016	— 0.007	+ 3.80	
1277	λ Leporis	B_2	4.29	78.75	— 13.27	+ 0.000	+ 0.003	+ 4.48	
1284	σ Orionis	B_3	4.65	79.18	— 0.47	— 0.005	— 0.003	+ 5.91	
1295	"	B_3	5.64	79.65	— 0.25	— 0.015	— 0.001	+ 3.82	
1301	η "	B_1	3.44	79.85	— 2.48	+ 0.006	+ 0.001	+ 7.49	
1303	γ "	B_2	1.70	79.95	+ 6.25	— 0.007	— 0.019	+ 3.80	0.005 G, F
1314	ψ "	B_2	4.66	80.40	+ 3.00	— 0.005	— 0.013	+ 2.53	0.003 G
1332	33 "	B_3	5.52	81.50	+ 3.20	+ 0.006	— 0.007	+ 3.65	
1339	δ "	B	2.48	81.72	— 0.37	+ 0.002	— 0.003	+ 4.86	0.003 F, Sm
1340	ν "	B	4.64	81.77	— 7.37	+ 0.003	— 0.012	+ 3.59	
1361	"	B_1	5.58	82.52	— 6.07	+ 0.002	+ 0.004	+ 6.12	
1370	ϵ "	B	1.75	82.77	— 1.25	+ 0.000	— 0.002	+ 5.17	0.003 F, C
1389	σ "	B	3.78	83.43	— 2.65	+ 0.006	+ 0.001	+ 5.28	
1398	ζ "	B	2.05	83.93	— 1.98	+ 0.003	— 0.007	+ 3.61	0.006 F, C
1399	"	B_3	5.00	83.95	— 1.17	— 0.012	— 0.003	+ 5.51	
(1435)	κ "	B	2.20	85.75	— 9.70	+ 0.003	— 0.005	+ 4.42	0.023 F, C
(1468)	α "	M_a	0.92	87.45	+ 7.38	+ 0.028	+ 0.003	+ 4.43	0.021 A, Y
	Nebula			83.60	— 5.45			+ 3.50	

C. THE χ - AND h -PERSEI-CLUSTER.

The parallax of this cluster has been determined by KAPTEYN⁶⁵ at 0".0007 and by V. SCHOUTEN¹⁰⁹ at $\pi = 0".004$ (from PIHL, SCHWARZSCHILD, VAN MAANEN). According to ADAMS and V. MAANEN⁵ 9 stars of the spectral-types *A* and *B* have exceptionally large and equal radial-velocities, with the mean $\bar{W} = -43.2 \pm 1.4$ km. The other stars have the spectral-types *F*, *K* and *G*. The proper motions of 1700 stars in the cluster have been measured by MACKLIN⁸⁵, and from their small values he concludes that the distance is very great. Fifteen stars between the magnitudes $m = +9^m.4$ and $m = +14^m.2$ seem to partake in the motion of the Perseus-cluster. KOSKINSKY⁷⁴ found 16 stars whose proper motions were $> 0".03$ and in the same direction with a mean position-angle of 110° . Separated in two groups, the first with 6 stars has the mean position-angle $130^\circ.6 \pm 2^\circ.1$ and the second with 7 stars $103^\circ.3 \pm 1^\circ.7$. These groups do not seem to be physically connected with the cluster, but nearer us. KAPTEYN (Groning. Publ. 10) gives a mean parallax of four stars $\pi = 0".07$.

D. THE VELA-GROUP.

The stars in the Vela do not share in the common motion of the other *B*-stars in this and neighbouring regions. There is no great probability that we should here have to do with a moving cluster.

The group consists of 15 stars, but is not homogeneous. PLUMMER⁹⁶ has divided the group into 3 groups with 5, 3 and 7 stars resp., and found for the groups the following convergents and velocities:—

$$\begin{array}{lll} A = 108^\circ, & D = -45^\circ, & \Omega = 25.6 \text{ km./sec.}, \\ A = 354^\circ, & D = +20^\circ, & \Omega = 7.9 \text{ } \\ A = 93^\circ, & D = -38^\circ, & \Omega = 15 \text{ } \end{array}$$

E. SOME POSSIBLE STAR-GROUPS.

Four possible star-groups are suggested by B. BOSS¹⁷, namely:—

GROUP A. ($\bar{\alpha} = 5^h40^m$, $\bar{\delta} = +21^\circ.4$, $\bar{\mu} = 0''.017$) with 16 stars of the spectral-types *B* and *A* (1 *M*), which converges towards a point about:— $A = 10^h$, $D = -45^\circ$.

GROUP B. ($\bar{\alpha} = 8^h21^m$, $\bar{\delta} = -43^\circ.9$, $\bar{\mu} = 0''.012$) with 12 stars of the spectral-types *A* and *B* (1 *G* and 1 *F*) which converges nearly towards antivertex.

GROUP C. ($\bar{\alpha} = 18^h59^m$, $\bar{\delta} = -16^\circ.6$, $\bar{\mu} = 0''.044$) with 6 stars of spectral-types *A* and *B* (1 *M*), which moves away from the antapex of solar motion.

GROUP D. ($\bar{\alpha} = 18^h59^m$, $\bar{\delta} = -32^\circ.3$, $\bar{\mu} = 0''.057$) with 7 stars of spectral-types *A* and *B* (1 *K*), which converges nearly towards the antapex.

The radial-velocities are known for 6 stars of the first group, with great variations from $+24.0$ km. to -17.1 , for two stars in group B ($+28.6$, $+20.5$), for one star in group C ($+22.0$) and for two stars in group D ($+1.4$, -1).

CHAPTER X.

A. THE STAR-STREAMING IN THE ENVIRONS OF CORONÆ BOREALIS.

For 25 stars between $\alpha = 14^h$ and $\alpha = 18^h$ RASMUSON¹⁰⁰ found by means of method II the convergent:—

$$A = 279^\circ.9, \quad D = -41^\circ.5,$$

or, excluding the 11 stars with greatest deviations in position-angle,

$$A = 276^\circ.0, \quad D = -40^\circ.5.$$

Only for two of the safe stars the radial-velocities were known, namely for α Coronæ + 6 km./sec. (CANNON) and for α Ophiuchi + 20 km./sec. (VOGEL v. SCHEINER), these also considerably corrected by later measures. The following table gives the values of the parallaxes and radial-velocities computed from the radial-velocity of α Ophiuchi together with the observed quantities from later measures. The great deviations made the existence of the group very doubtful. The proper motions and coordinates of the stars were taken from the "Catalogue de mouvements propres de 2641 étoiles" par M. J. BOSSERT and Berliner Astr. Jahrbuch 1911.

TABLE XVII.
THE CORONA-STREAM.

Star-name	Sp.	<i>m</i>	α	δ	w_c (km./sec.)	w_0	π_c	π_0
Lal. 32790...	<i>F</i> ₅	4.90	265°98	+ 72°20	— 12.6	— 10.4 L	0.044	[0.044] 0.030 A
» 28017...	<i>G</i>	5.23	228.37	+ 67.73	— 15.8	— 46.4 L, B, W	0.055	
» 32324...	<i>G</i> ₀	4.0	263.49	+ 61.95	— 10.4		0.057	[0.055] 0.084 A, Ye, M, Y
» 26880...	<i>G</i> ₀	7.4	219.59	+ 58.39	— 8.0		0.055	[0.028]
Gr. 2131...	<i>F</i>	6.25	217.81	+ 57.51	— 8.0		0.055	
Pi. 235...	<i>F</i>	5.68	223.26	+ 50.04	— 4.2		0.060	
Lal. 32215...	<i>K</i>	5.54	263.48	+ 48.52	+ 0.1		0.066	
» 28600...	<i>A</i> ₈	5.78	233.77	+ 47.18	— 5.2	— 2.3 W	0.060	
» 26515...	<i>G</i>	6.45	216.42	+ 42.25	— 6.3		0.060	
» 26347...	—	—	214.87	+ 39.79	— 2.6		0.060	
» 32322...	<i>F</i> ₀	8.5	264.06	+ 37.26	+ 14.6		0.060	[0.018]
» 30664...	—	—	251.27	+ 37.20	+ 5.0		0.060	
» 31618...	<i>G</i>	5.36	259.23	+ 32.59	+ 24.0	— 78.4 W	0.060	[0.105] 0.087 A, S, Y, F
» 28100...	<i>G</i>	$\begin{cases} 5.58 \\ 6.08 \end{cases}$	229.77	+ 30.65	+ 2.4	— 9.7 Y	0.060	[0.055] 0.084 S, Ye
α Coronæ...	<i>A</i>	2.31	232.75	+ 27.01	+ 2.7	+ 0.4 orb.	0.060	
Lal. 27570...	<i>A</i> ₈	5.03	225.73	+ 25.25	+ 3.3	— 7. L	0.060	[0.046] 0.059 A
» 32390...	—	—	264.76	+ 21.67	+ 28.0		0.055	
γ Serpent...	<i>F</i> ₈	3.86	237.96	+ 15.99	+ 62.5		0.065	[0.120] 0.063 A, M, Y
α Ophiuchi...	<i>A</i> ₈	2.14	262.51	+ 12.62	+ 20.0	Bin.	0.046	
Lal. 29437...	<i>F</i> ₅	6.02	241.07	+ 6.66	+ 48.8	— 2.3 W	0.049	[0.048] 0.014 Y, K
» 27917...	<i>G</i>	5.18	228.55	+ 2.14	+ 33.6	+ 53.3 L, B	0.053	[0.046] 0.055 A, Y
» 26289...	<i>G</i>	6.34	214.53	+ 1.70	+ 16.9	— 17.8 W	0.059	[0.076] 0.070 Y, F
» 30191...	<i>F</i>	5.87	247.78	— 2.11	+ 52.1		0.044	[0.087] 0.088 A
» 28334...	<i>K</i>	4.88	232.17	— 9.72	+ 32.3	+ 48.6 L, C	0.046	[0.042]
57 Hydre...	<i>B</i> ₀	5.80	220.53	— 26.23	+ 16.2		0.044	

B. THE STAR-STREAMING IN THE ENVIRONS OF COMÆ BERENICE.

With stars from the Greenwich-catalogue, which is complete for the zone $\delta = +24^\circ$ to $+32^\circ$, augmented by a few stars from the Boss-catalogue, I have made an investigation into the stars between $\alpha = 11^h$ and $\alpha = 15^h$.

There is a well marked star-streaming in the direction towards a point anywhere between apex and vertex (fig. XII). The motions, then, seem to be nearly entirely parallactic. Together with the outside stars from the catalogue of BOSS the Greenwich-stars are grouped in three parallel groups and the convergent determined to be:—

$$A = 92^\circ, \quad D = -6^\circ,$$

with a mean deviation in the position-angle of ± 8.5 . Excluding the stars with proper motions $> 0''.1$ I get:—

$$A = 85^\circ, \quad D = -10^\circ.$$

TABLE XVIII.

	I	II	III
n	5 (Boss)	13 (Greenwich)	13 (Greenwich)
$\bar{a}$	— 4.206	— 2.413	— 2.989
$\bar{b}$	— 0.685	— 0.752	— 0.581
$\bar{c}$	— 5.725	— 5.398	— 5.446

Of the 17 Boss-stars there are 13 with the spectral-type A. No further calculations are made because of the great irregularity in the radial-velocities which are known for 8 Boss-stars.

An examination of the proper motions in the cluster of Comæ Berenice has been made by FAGERHOLM⁴⁴, who found for the principal stars in the cluster a nearly parallel motion “in westward direction with a slight deviation toward the north”.

PICKERING⁹⁰ has determined the parallax of the cluster to be $\pi = 0''.0109$ (with the formula of RUSSELL).

TABLE XIX.

THE BERENICE-GROUP.

Boss	Sp.	m	α	δ	u	v	w (sir.)	Δq
3102	F	5.8	176.1	+ 35.5	— 0.118	— 0.012		+13.7
3229	A	6.0	184.7	+ 43.1	— 0.083	+ 0.005		— 6.0
3283	A	4.8	187.5	+ 23.2	— 0.072	+ 0.007	— 4.2	— 9.0
3306	A	6.8	189.1	+ 11.0	— 0.114	— 0.002		— 5.6
3323	A	5.2	190.2	+ 8.2	— 0.113	+ 0.001	— 1.9	— 5.3
3338	A	6.2	191.0	+ 49.0	— 0.055	+ 0.003	— 0.5	— 0.3
3339	A	5.8	191.1	+ 28.1	— 0.094	+ 0.011	+ 0.3	— 7.8
3343	A	5.9	191.4	+ 38.1	— 0.099	+ 0.014		— 7.0
3432	K	5.1	197.3	+ 40.7	— 0.044	— 0.001		+ 6.7
3439	A ₅	5.7	197.8	+ 41.4	— 0.118	— 0.001		+ 6.3
3447	F	4.7	198.3	+ 41.1	— 0.126	+ 0.004	+ 2.0	+ 3.1
3466	A	6.4	199.4	+ 44.4	— 0.074	+ 0.000		+ 8.0
3512	A ₅	4.6	202.6	+ 49.5	— 0.118	+ 0.015	— 3.4	+ 4.8

Boss	Sp.	<i>m</i>	α	δ	<i>u</i>	<i>v</i>	<i>w</i> (sir.)	Δq
3518	<i>F</i>	4.9	203.8	+ 36.8	— 0.108	+ 0.014	— 1.8	+ 0.4
3526	<i>A</i>	5.5	203.7	+ 11.8	— 0.112	— 0.011	— 4.9	+ 3.6
3591	<i>A</i>	5.8	207.2	+ 29.1	— 0.118	+ 0.014		+ 0.4
3613	<i>A</i>	6.1	209.2	+ 27.9	— 0.080	+ 0.003		+ 6.0
Greenw.								
5306	<i>F</i> ₈	8.6	164.7	+ 31.7	— 0.104	— 0.004		— 12.2
5307	<i>A</i> ₅	6.9	164.7	+ 26.8	— 0.117	+ 0.002		— 14.0
5365		9.2	167.6	+ 27.5	— 0.119	— 0.002		— 11.2
5366-67	<i>A</i> ₅	7.1	167.6	+ 28.1	— 0.061	+ 0.006		— 15.5
5386	<i>G</i> ₅	9.6	168.5	+ 25.8	— 0.091	— 0.008		— 6.4
5409		9.6	169.8	+ 25.5	— 0.088	— 0.005		— 7.5
5414		9.8	170.0	+ 30.6	— 0.116	— 0.008		— 7.4
5441	<i>F</i> ₅	8.7	171.2	+ 26.4	— 0.067	+ 0.001		— 7.9
5443	<i>G</i>	9.0	171.2	+ 27.1	— 0.059	+ 0.002		— 12.4
5446	<i>F</i> ₅	7.9	171.3	+ 25.4	— 0.054	+ 0.005		— 12.4
5453	<i>M</i> _a	7.0	171.5	+ 29.0	— 0.091	+ 0.008		— 11.7
5454	<i>F</i> ₈	8.3	171.6	+ 28.0	— 0.061	+ 0.000		— 6.4
5465		9.6	172.2	+ 30.1	— 0.082	— 0.007		— 5.8
5498	<i>A</i> ₃	6.8	173.9	+ 24.2	— 0.078	+ 0.002		— 6.5
5499		8.9	173.9	+ 31.9	— 0.078	+ 0.001		— 10.1
5506		9.6	174.0	+ 30.6	— 0.057	— 0.002		— 7.2
5560-61		8.2	177.1	+ 31.8	— 0.090	+ 0.009		— 13.8
5567-68		8.8	177.4	+ 25.2	— 0.054	— 0.005		— 12.7
5572	<i>K</i> ₀	7.0	177.7	+ 26.0	— 0.057	— 0.005		— 2.2
5591		9.6	178.4	+ 30.8	— 0.065	— 0.005		— 2.5
5614	<i>F</i> ₈	8.8	179.4	+ 31.8	— 0.051	— 0.003		— 3.1
5675		9.6	182.2	+ 27.5	— 0.092	+ 0.006		— 8.9
5701		9.8	183.6	+ 31.0	— 0.059	+ 0.002		— 7.8
5711	<i>K</i> ₂	8.8	183.9	+ 31.0	— 0.081	+ 0.000		— 4.2
5724	<i>F</i> ₃	8.8	184.3	+ 25.0	— 0.061	+ 0.004		— 8.2
5750	<i>K</i> ₀	7.7	185.1	+ 31.5	— 0.061	+ 0.007		— 10.0
5872		8.8	190.0	+ 25.8	— 0.084	+ 0.009		— 8.2
5893	<i>F</i> ₀	7.1	190.9	+ 30.0	— 0.079	+ 0.003		— 6.5
5898	<i>K</i> ₀	7.7	191.0	+ 30.9	— 0.058	+ 0.005		— 5.5
5935		9.6	192.7	+ 29.2	— 0.055	+ 0.007		— 7.3
5991	<i>G</i> ₅	9.2	195.0	+ 30.7	— 0.061	— 0.003		+ 4.8
5993		10.0	195.0	+ 26.8	— 0.050	+ 0.004		— 4.2
6016	<i>G</i> ₅	9.6	195.8	+ 29.9	— 0.060	— 0.001		+ 2.8
6033		8.9	196.6	+ 29.0	— 0.115	— 0.009		+ 6.8
6034		9.2	196.6	+ 29.2	— 0.093	+ 0.008		— 2.1
6063	<i>G</i> ₅	9.8	198.2	+ 31.6	— 0.116	— 0.005		+ 5.8
6106	<i>K</i> ₀	7.4	199.9	+ 26.0	— 0.050	+ 0.000		+ 2.4
6123	<i>K</i> ₀	8.2	200.8	+ 29.3	— 0.063	— 0.007		+ 10.4
6138		10.9	201.8	+ 25.0	— 0.056	+ 0.002		+ 0.6
6149		9.7	201.8	+ 27.7	— 0.076	+ 0.006		— 0.7
6172	<i>F</i> ₈	8.8	202.7	+ 30.6	— 0.052	— 0.001		+ 6.5
6215	<i>G</i> ₀	8.8	205.0	+ 25.7	— 0.105	— 0.011		+ 10.7
6222	<i>K</i> ₀	8.6	205.4	+ 31.1	— 0.069	— 0.006		+ 16.0
6277	<i>F</i> ₂	7.4	207.6	+ 30.4	— 0.051	— 0.004		+ 12.5
6307	<i>A</i> ₃	6.1	209.2	+ 27.8	— 0.080	+ 0.003		+ 7.5
6325		9.5	210.4	+ 30.0	— 0.091	— 0.001		+ 10.0
6332	<i>K</i> ₀	7.0	210.7	+ 28.9	— 0.062	+ 0.005		+ 4.5
6366		9.6	212.2	+ 26.2	— 0.067	+ 0.001		+ 8.6
6409		9.2	213.9	+ 30.1	— 0.062	+ 0.006		+ 6.0
6424		9.0	214.4	+ 24.6	— 0.049	+ 0.000		+ 8.6
6460		9.8	215.8	+ 30.6	— 0.049	+ 0.003		+ 9.4
6464		9.2	216.0	+ 27.9	— 0.052	+ 0.002		+ 9.8
6467	<i>G</i> ₈	7.6	216.0	+ 29.7	— 0.055	+ 0.003		+ 9.5
6535	<i>G</i> ₅	8.8	218.9	+ 31.5	— 0.054	+ 0.001		+ 14.6
6557		9.2	219.8	+ 25.4	— 0.053	— 0.002		+ 14.1
6571		8.4	220.8	+ 25.1	— 0.064	+ 0.002		+ 10.2
6632	<i>F</i> ₈	8.9	223.1	+ 29.8	— 0.069	+ 0.005		+ 13.8
6657		9.8	224.5	+ 25.2	— 0.069	+ 0.004		+ 11.4

CHAPTER XI.

REVIEW OF THE RESULTS.

Four of the moving clusters investigated in this paper consist mainly of *B*-stars, namely the Perseus-cluster, the Pleiades, the Scorpio-Centaurus-cluster and the Orion-cluster. Four clusters consist mainly of *A*-stars, namely the Taurus-cluster, the Ursa major-cluster, the Præsepe, the α Lyra-cluster.

The mean values of the absolute magnitudes of the stars computed in these clusters are collected in the following table together with the dispersion.

TABLE XX.

Cluster	Author	B_0-B_6	B_8-B_9	A
Perseus	BOTTLINGER	$-1^m.75$		
	RASMUSON	-1.88 ± 1.07	-0.88 ± 0.51	-0.55 ± 0.66
Pleiades	PLUMMER	$+0.3$	$+0.0$	
	RASMUSON	-1.73 ± 0.81	-0.71 ± 0.72	
Scorpio-Centaurus ...	KAPTEYN	-0.68 ± 1.8	$+0.43 \pm 1.39$	
	RASMUSON	-2.07 ± 1.24	-0.61 ± 0.77	-0.20 ± 0.73
(Orion)	RASMUSON	-3.96		
Taurus	KAPTEYN			$+1.38 \pm 0.9$
	MALMQUIST			$+0.60 \pm 0.65$
	RASMUSON			$+0.68 \pm 0.67$
Ursa major	BOTTLINGER (20 st.)			$+0.21$
	MALMQUIST (12 st.)			-0.62 ± 0.97
	MALMQUIST (10 st.)			-0.38 ± 0.87
	RASMUSON (15 st.)			-0.58 ± 0.90
(α -Lyrae)	RASMUSON		-0.77	$+1.20$

For the absolute magnitudes of *B*- and *A*-stars (generally) the following values have been obtained by different authors.

$$\begin{aligned}
 \text{CHARLIER}^{28} \dots\dots B_0-B_5: M_0 &= -3.4, \\
 &B_1-B_2: M_0 = -4.3, \\
 \text{KAPTEYN}^{66} \dots\dots B_0-B_5: M_0 &= -1.1, \\
 &B_8-B_9: M_0 = +1.1, \\
 &A: M_0 = +1.9,
 \end{aligned}$$

MALMQUIST ⁸⁶	$B_8-A_5: M_0 = -0.2,$
DYSON ⁸⁷	$B_8-B_9: M_0 = -0.2,$
	$A_0: M_0 = +0.7,$
PLUMMER ⁹⁴	$B-B_2: M_0 = -3.9,$
	$B_3-B_5: M_0 = -2.4,$
	$B_8-B_9: M_0 = -2.2,$
	$A: M_0 = -1.0,$
	$A_1-A_3: M_0 = -0.3,$
	$A_5-A_8: M_0 = +1.0,$
SEELIGER ⁹⁴	$B: M_0 = -1.9,$
	$A: M_0 = +0.9.$

In table XXI other results are collected:—

TABLE XXI.

	Year	<i>n</i>	<i>A</i>	<i>D</i>	Ω km./sek.	π	<i>L</i> ₀	<i>B</i> ₀	<i>a</i> ₁	$\frac{L_1}{B_1}$	<i>a</i> ₂	$\frac{L_2}{B_2}$	<i>a</i> ₃	$\frac{L_3}{B_3}$
TAURUS-CLUSTER.														
BOSS	1875	39	91°8	+ 6°9										
"	"	3			45.6	0".025								
KAPTEYN	1904	62				0.023								
PLUMMER	1912	19	87.0	+ 7.3	37.9									
HERTZSPRUNG	1909	7	92.3	+ 7.1	44.0									
"	1918	41				0.027								
KAPTEYN	"		86.5	+ 8.7		0.038								
RASMUSON	1921	39	93.2	+ 7.0										
"	"	15			40.5	0.0275	148°8	+11°1	0.59	91°9	0.41	3°9	0.74	0°1
										0.0		—80.3		+9.0
URSA MAJOR-CLUSTER.														
KLINKERFUES	1878	5	218.9	+44.4		0.026								
HÖFFLER	1897	5	303.7	—34.9										
"	"	4			45.9	0.017								
KOBOLD	1906	5	318.7	—56.0										
LUDENDORFF	1909	5	303.2	—36.6										
"	"	2			20.7	0.035								
HERTZSPRUNG	"	10	307.8	—40.2										
"	"	4			18.4									
LUDENDORFF	"	10	309.2	—41.7										
"	"	8	309.3	—42.2										
"	"	5			19.8									
"	"	3			18.6									
BOTTLINGER	1914	17	307.9	—40.0										
"	"	5			18.4									
RASMUSON	1921	17	307.6	—39.9			0.0	—7.6	3.86	220.7	5.69	320.6	2.16	306.3
"	"	1			18.6					+6.5		+56.1		—33.0
"	"	28							4.54	239.1	5.90	319.2	2.72	323.1
										+4.7		+73.4		—24.8
PRÆSEPE.														
SCHWARZSCHILD	1914	6				0.0063								
BOSS	1917	9	71.3	—15.0										
V. SCHOUTEN	1919					0.024								
KOHLSCHÜTTER	1920	24				0.0072								
RASMUSON	1921	5	106.3	+ 6.3	40.4	0.011	153.0	+28.0						

	Year	<i>n</i>	<i>A</i>	<i>D</i>	Ω km./sek.	π	<i>L</i> ₀	<i>B</i> ₀	<i>a</i> ₁	$\frac{L_1}{B_1}$	<i>a</i> ₂	$\frac{L_2}{B_2}$	<i>a</i> ₃	$\frac{L_3}{B_3}$
THE PLEIADES.														
KAPTEYN	1912	6				0.018								
PLUMMER	1913	6	79°0	—33°4	12.0	0.033								
HERTZSPRUNG..	»	12				0.024								
»	»	26				0.014								
HARTMAN	1914	11				0.006								
HAYN	»	10				0.011—0.017								
BOSS	1915	107.0	—40.0			0.013								
»	1917	10	71.3	—15.0										
PICKERING	1918	76				0.005								
V. SCHOUTEN ...	1919					0.036								
TRÜMPLER	1920	6				< 0.002								
RASMUSON	1921	11	84.8	—43.3			323.3	—5.3						
»	»	6			19.5	0.014								
PERSEUS-CLUSTER.														
PLUMMER	1913	5	106.0	—30.0	14.9									
BOSS	1915		107.0	—40.0										
BOTTLINGER ...	1921	18	107.0	—26.0										
»	»	7			21.5	0.009								
RASMUSON	»	29	110.3	—28.7					3.97	348.3	4.64	79.2	2.42	169.0
»	»	15			20.7		175.9	+1.0		—82.6		—0.2		—6.6
SCORPIO CENTAURUS-CLUSTER.														
PLUMMER	1913	24	96.0	—39.0	14.8									
KAPTEYN	1914	96	98.8	—41.5										
»	»	35			15.3									
RASMUSON	1921	131	99.1	—45.4			313.7	+9.8	7.24	347.0	4.70	259.1	3.09	16.7
»	»	109	98.2	—43.6						+13.9		—7.3		—74.0
»	»	38			18.6									
ORION-CLUSTER.														
KAPTEYN	1918	25	81.2	—1.4		0.0054								
BERGSTRAND ...	1919	18				0.008								
RASMUSON	1921	17	78.4	—17.9	18.3	0.0055	80.0	—9.0						
α LYRÆ-CLUSTER.														
DZIEWULSKI ...	1916	3	68.8	+6.9	19.8		88.0	—4.0						
61 CYGNI-CLUSTER.														
BOSS	1911	12	99.2	+0.5										
»	»	6			95.0		173.0	+5.5						
CORLIN	1920	4			56.5									
»	»	4			82.5									
»	»	3			103.0									
RASMUSON	1921	57							6.8	169.2	9.0	72.0	4.7	340.4
									+80.6		+2.7			+1.4
MONOCEROS-CLUSTER.														
CORLIN	1920	5	93.3	—12.5										
»	»	1			62.0									
STROOBANT'S CLUSTER.														
RASMUSON	1921	7	271.6	+42.1	1.8									
CORONA-CLUSTER.														
RASMUSON	1911	25	279.9	—41.5										
»	»	14	276.0	—40.5										
BERENICE-CLUSTER.														
RASMUSON	1921	78	92.0	—6.0										
»	»	31	85.0	—10.0										

SUMMARY.

(1) The capacity of forming moving clusters seems to be confined especially to the stars with great masses of the spectral-types *B* and *A*, mixed sometimes with a small number of giants from the later types. The fainter stars originally connected with the cluster have had greater chances of being lost at the collisions with other clusters.

(2) The mean absolute magnitudes of the stars in the moving clusters are:—

$$B0-B5: M_0 = -2^m_{02},$$

$$B8-B9: M_0 = -0^m_{65},$$

$$A: M_0 = +0^m_{00}.$$

The *A*-stars associated with stars of the spectral-type *B* (Perseus, Scorpio-Centaurus) are brighter than the *A*-stars associated with stars of later spectral-types (Taurus).

(3) The position of the convergents of the absolute motion shows that the motion of the clusters is in close relation to the galactic plane.

(4) While the density of the stars in the three clusters of Ursa major, Perseus Scorpio-Centaurus is less than 0.1 stars pro cubic-siriometer, the density in the Taurus-cluster is nearly 15 stars pro cubic-siriometer. It is possible that we have to do with two different species of clusters.

(5) The deformations of the clusters by encounters with other clusters are shown with greatest evidence in the Ursa major-cluster and the Perseus-cluster, which are flattened at right angles to the direction of motion, which, according to JEANS, ought to be the consequences of head-on-encounters with other moving clusters with rather great relative motion. The Scorpio-Centaurus-cluster seems, then, to have been a victim to several side-on-encounters and perhaps penetrated by smaller clusters, with the result of a diminished density in certain parts of the cluster. The total result is that it is lengthened in the direction of its own motion. The Taurus-cluster shows no great differences between the axes.

(6) There are great reasons to exclude from the list of moving clusters the 61 Cygni-stream and other clusters of fainter stars of later spectral-types, whose existence is not confirmed by later researches.

(7) The apparent motion of the *B*-star-clusters is directed nearly towards the antapex of the solar motion (determined by CHARLIER from the *B*-stars to be:— $A = 93^m_{48}$, $D = -34^m_{42}$, with $\Omega = -21.26$ km.). The absolute motions are small (5 to 6 km./sec.). The clusters, then, seem to be practically at rest in space.

In concluding I wish to express my hearty thanks to Professor C. V. L. CHARLIER, who has suggested to me to undertake this investigation and who has followed it with his warmest interest. I am also indebted to Docent G. MALMQUIST for valuable suggestions and advices and to Docent W. GYLLENBERG, Amanuens J. B. OHLSSON and Amanuens A. CORLIN.

OBSERVATORY LUND 1921.

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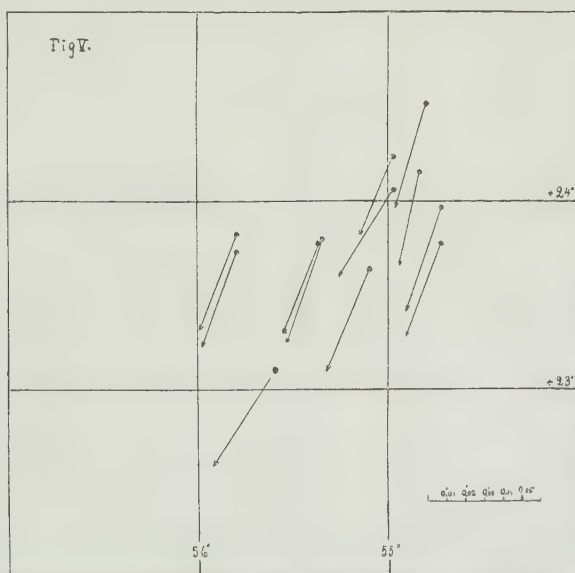
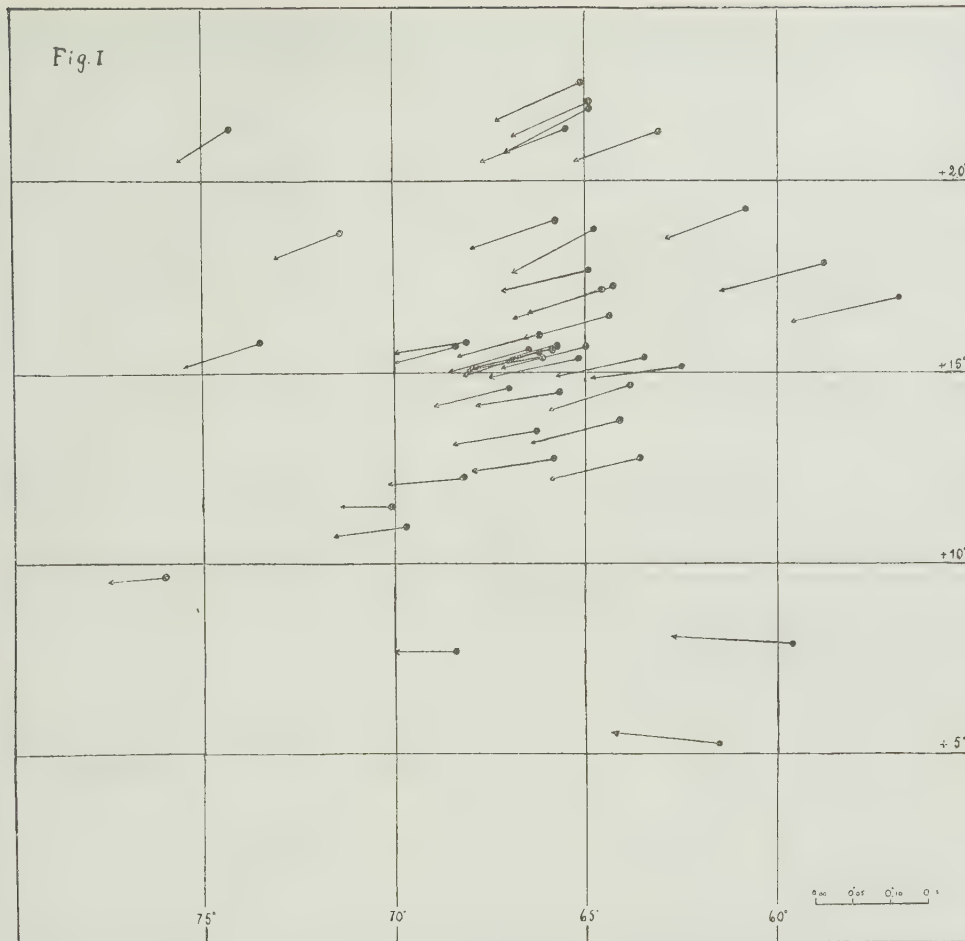
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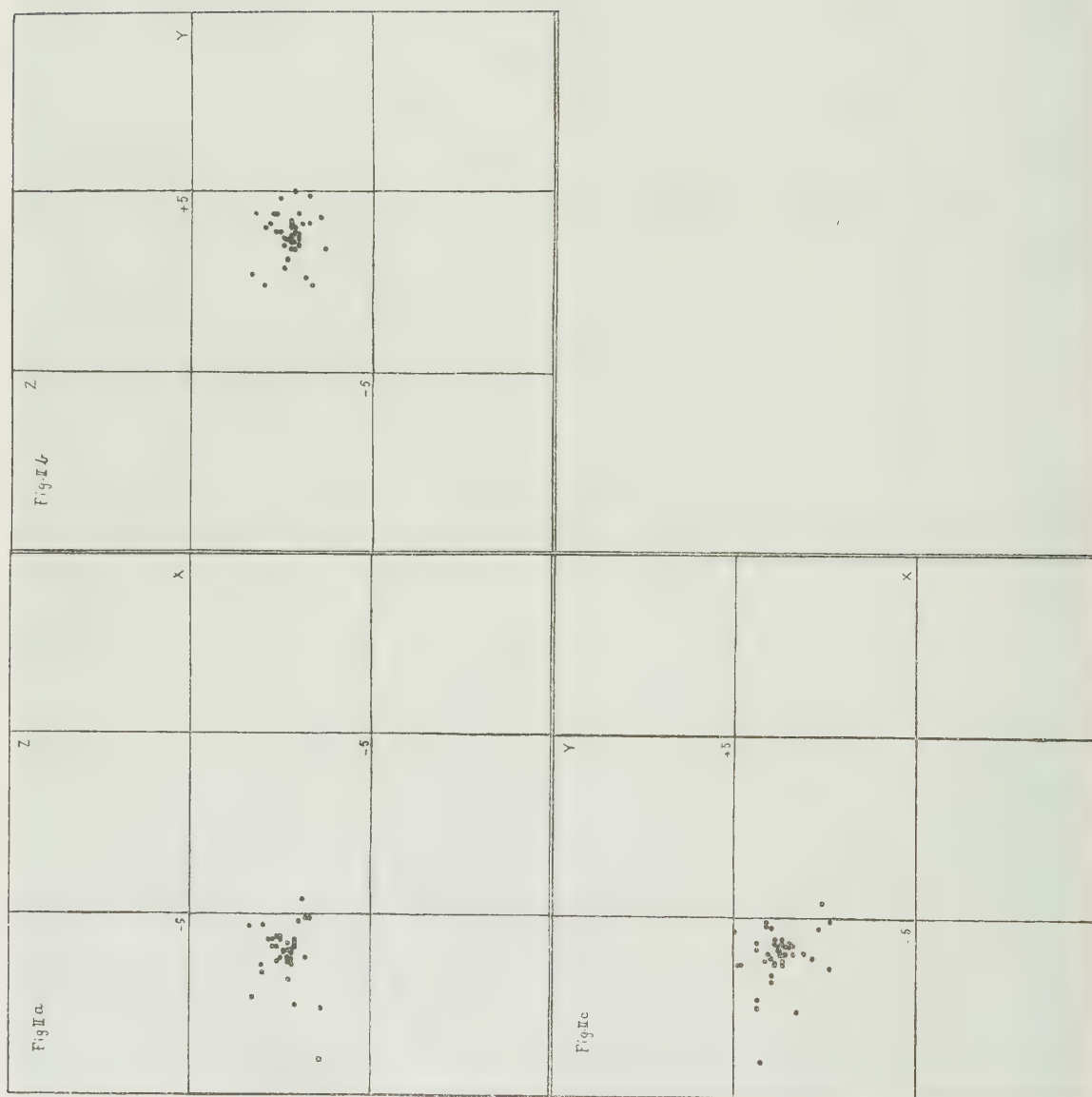
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FIG. I and FIG. V.



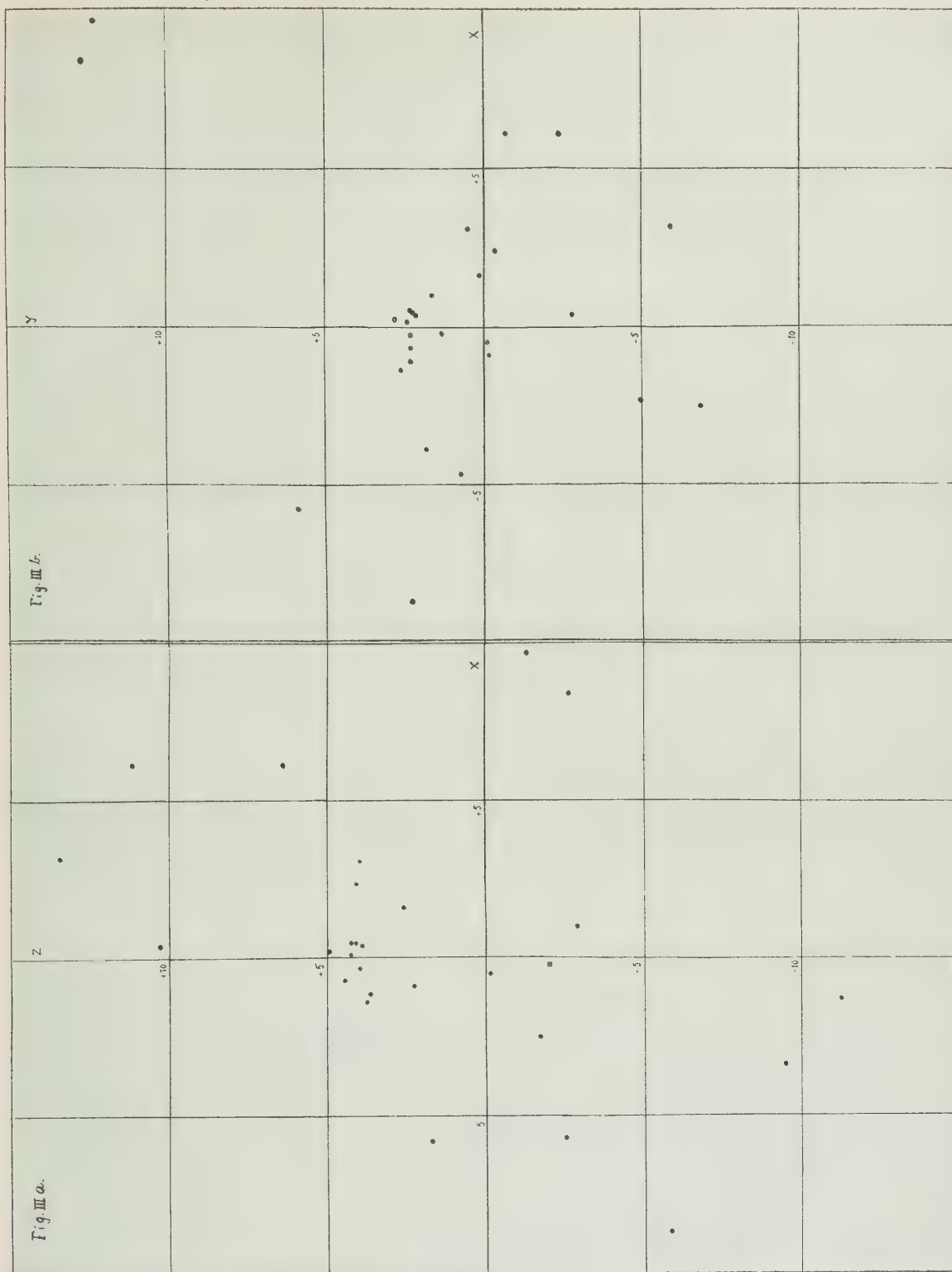
(Fig. I.) *The Taurus-cluster.*

(Fig. V.) *The Pleiades.*

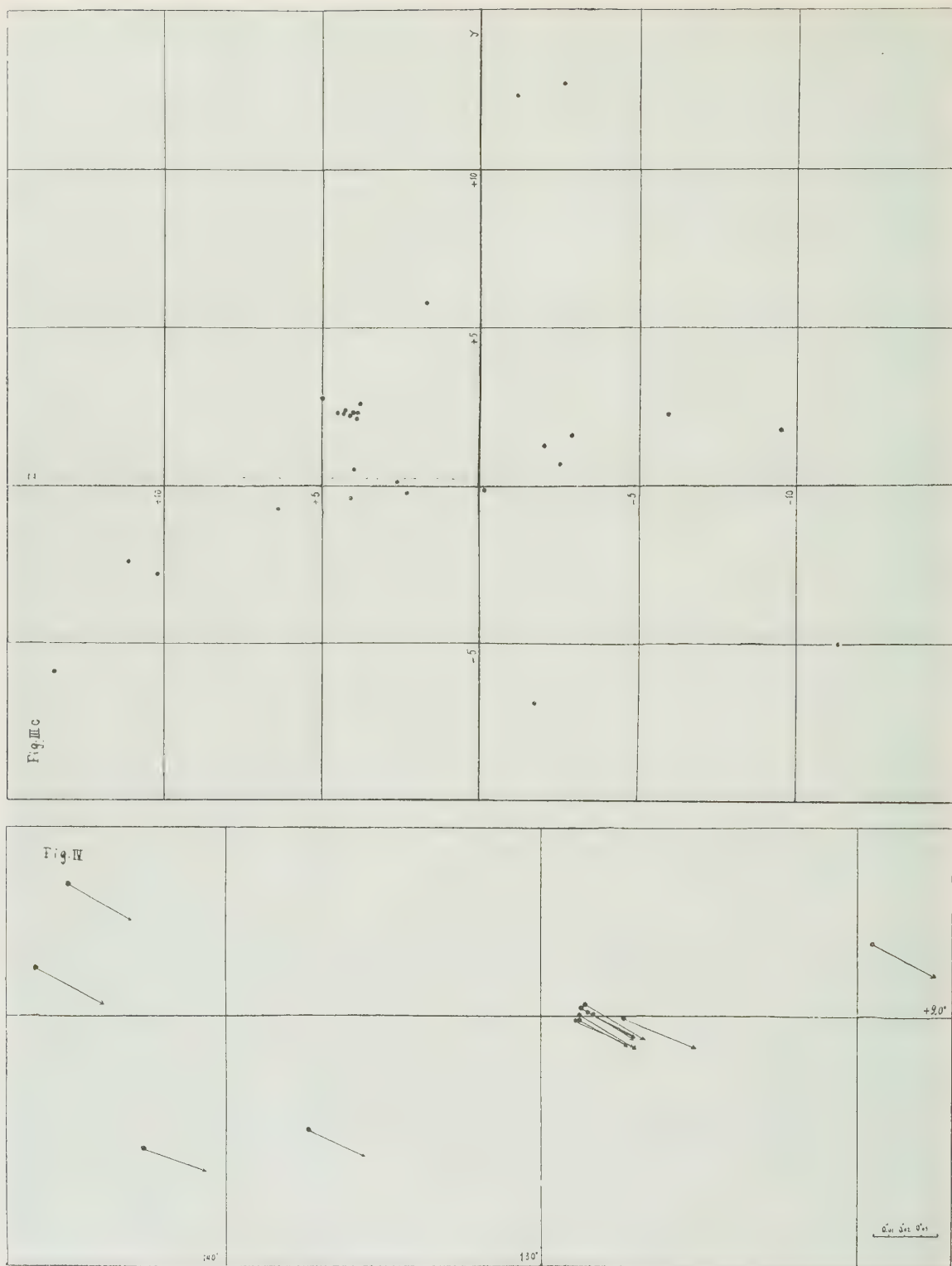


The Taurus-cluster, distribution in space.

FIG. IIIa and b.



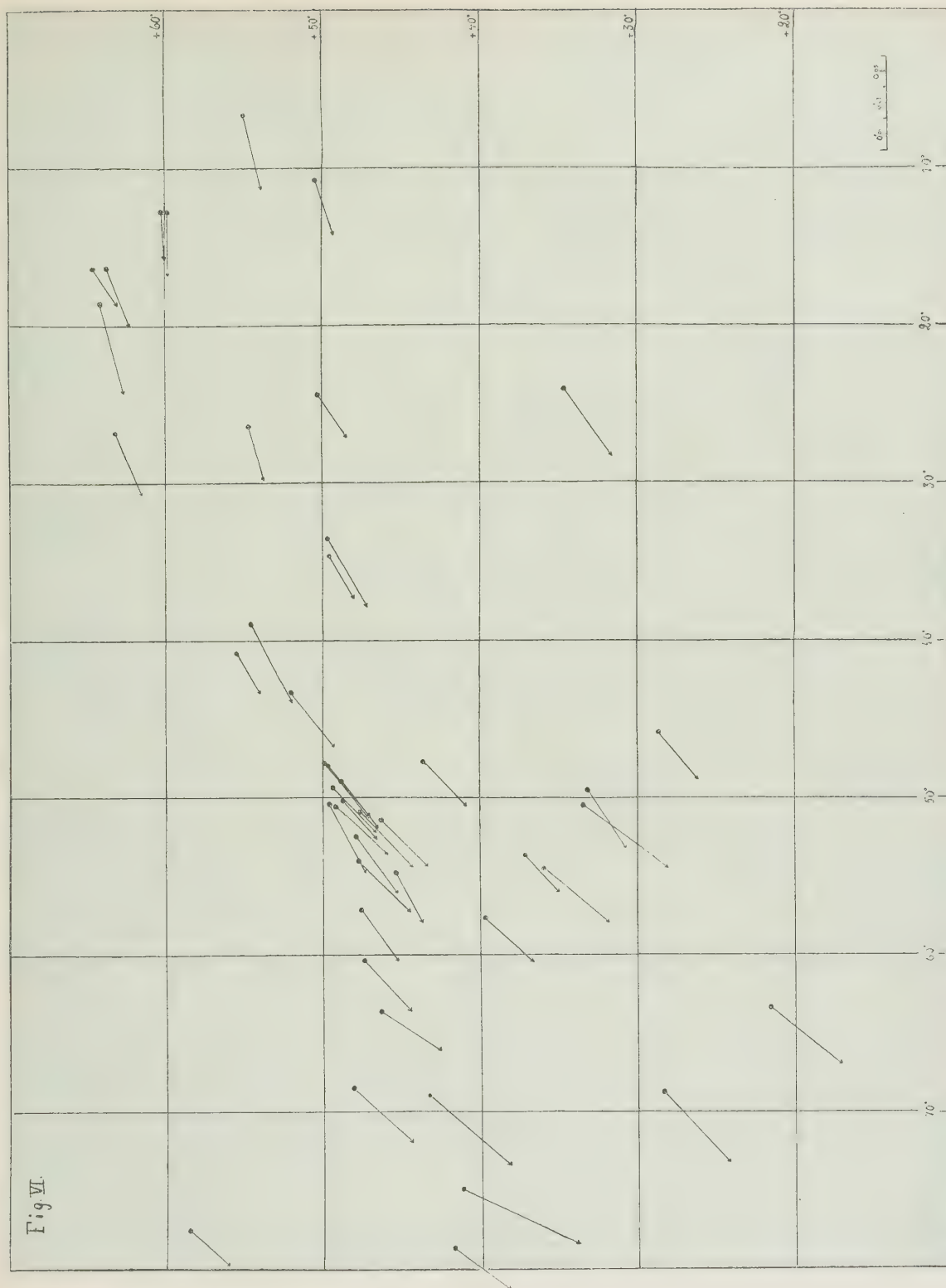
The Ursa major-cluster.



(Fig. IIIc.) *The Ursa major-cluster.*

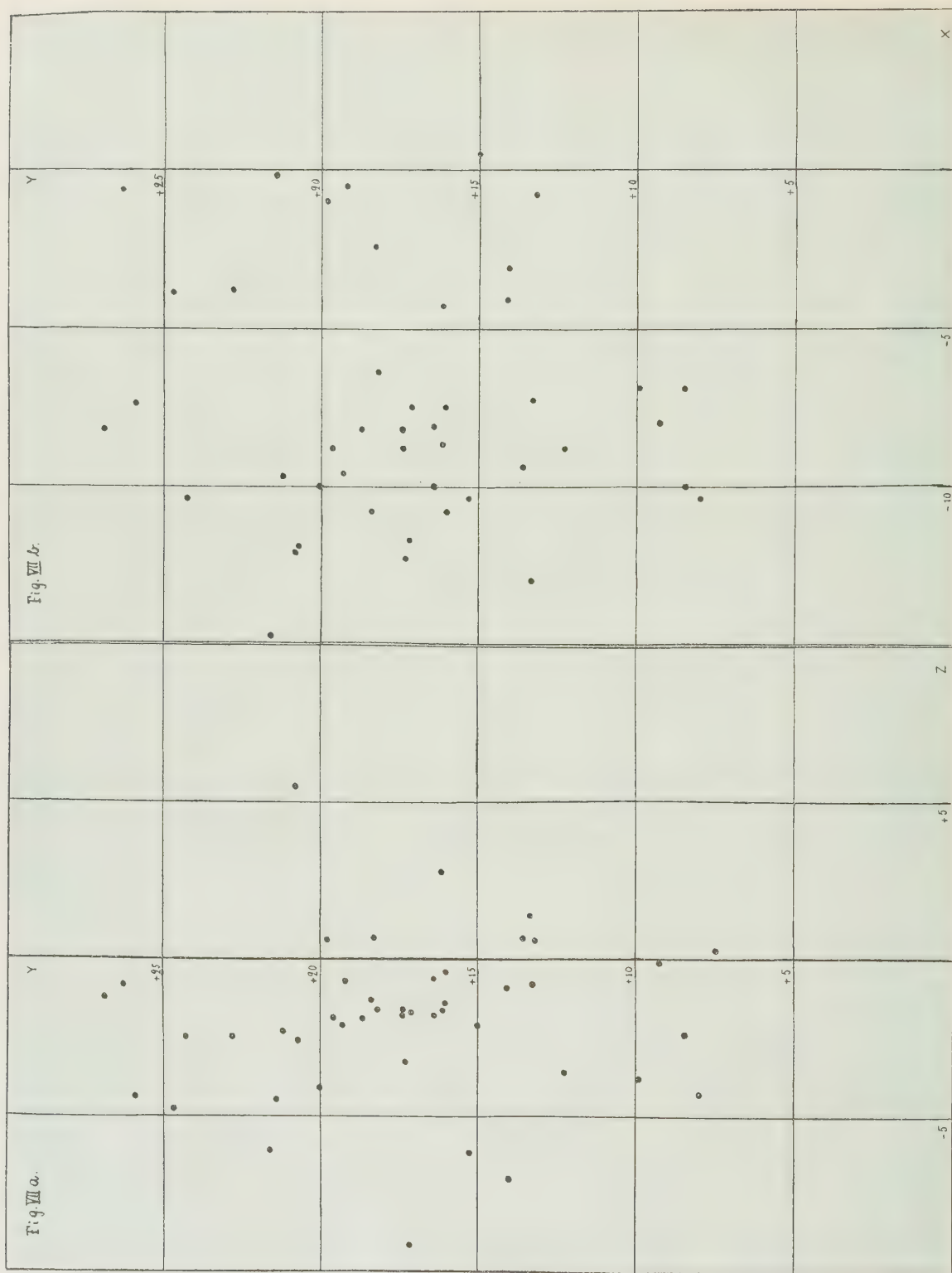
(Fig. IV.) *The Præsepe-cluster.*

FIG. VI.

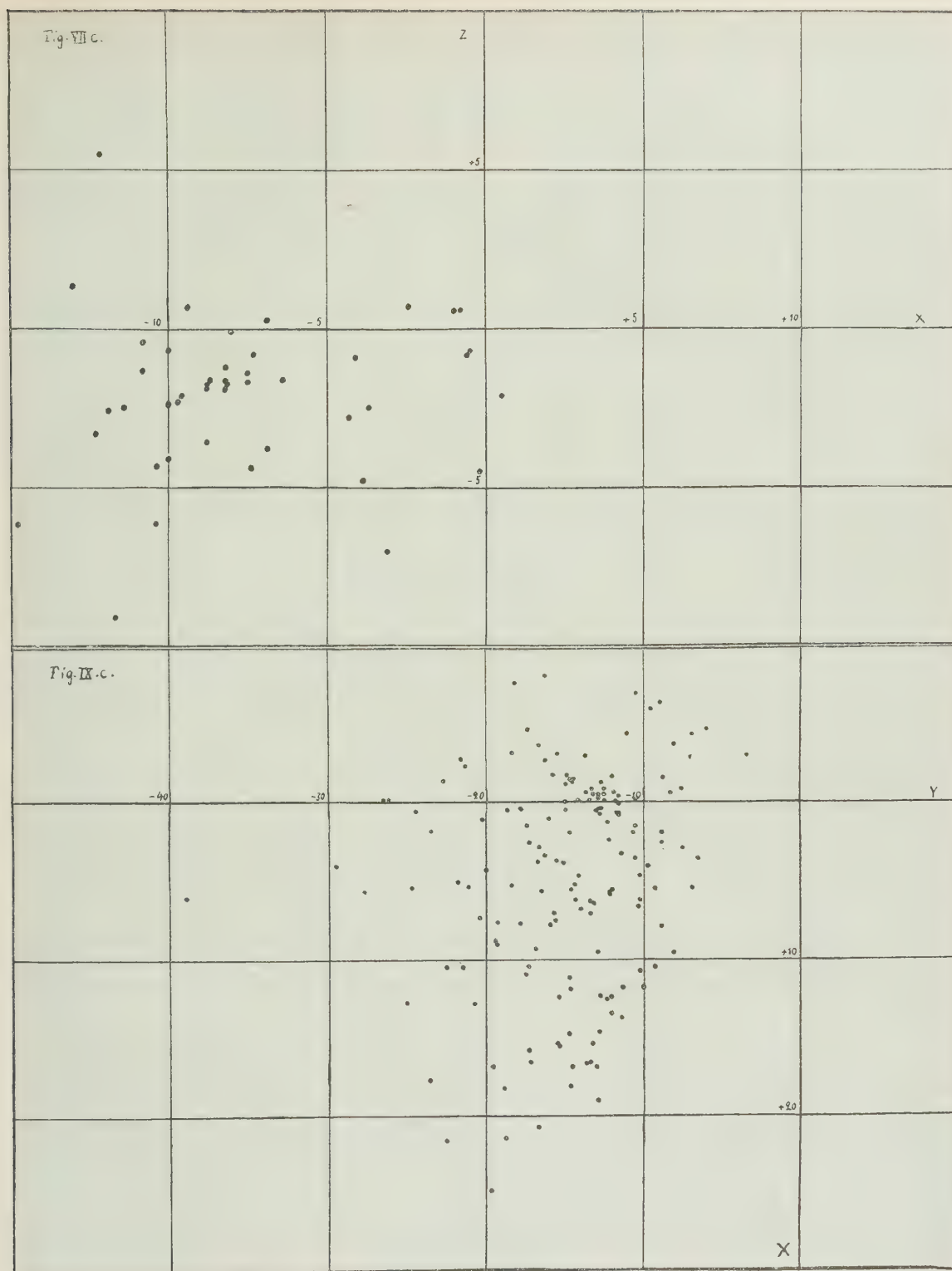


The Perseus-cluster.

FIG. VIIa and b.



The Perseus-cluster, distribution in space.



(Fig. VIIc.) *The Perseus-cluster, distribution in space.*

(Fig. IXc.) *The Scorpio-Centaurus-cluster, distribution in space.*

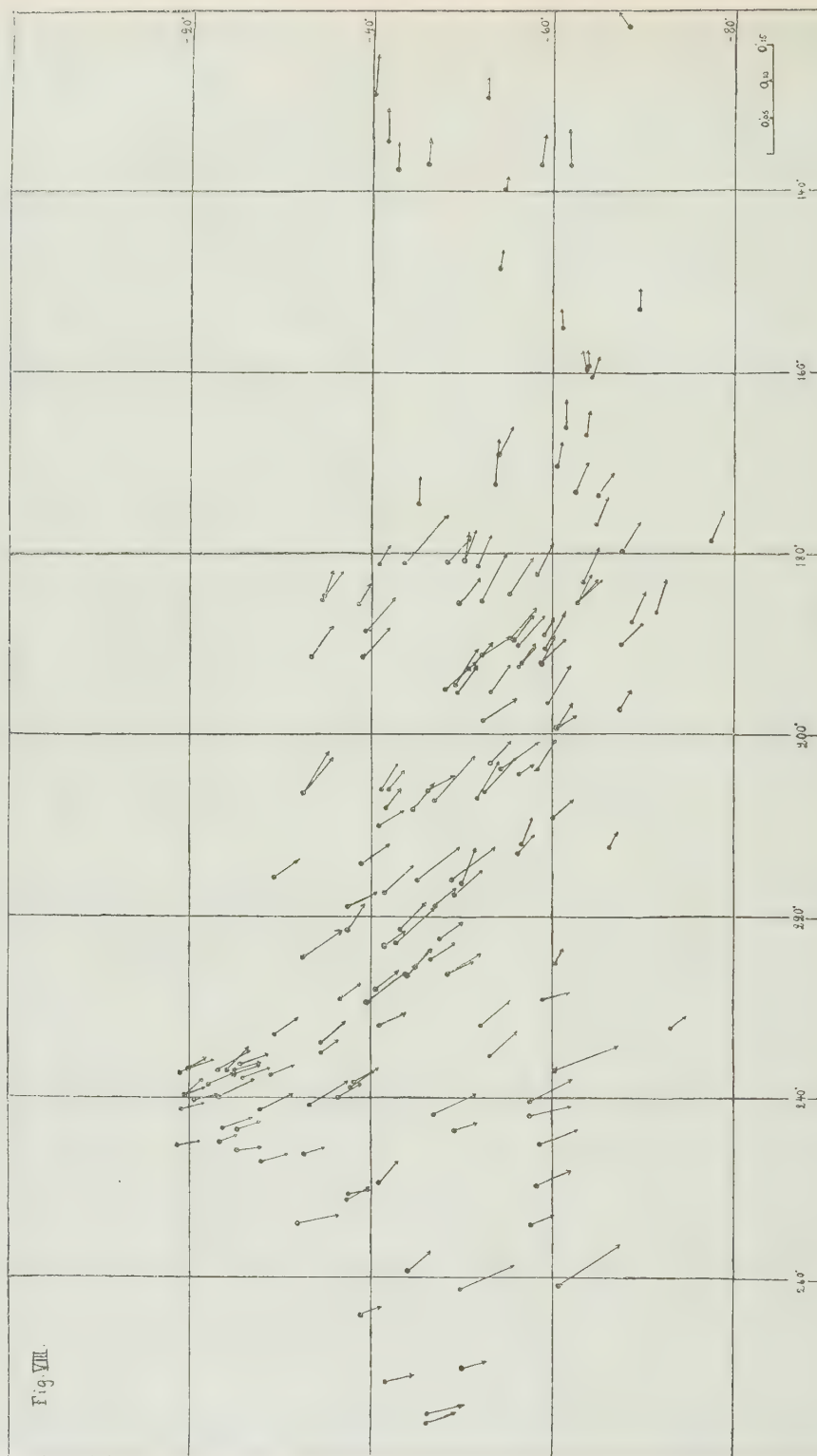
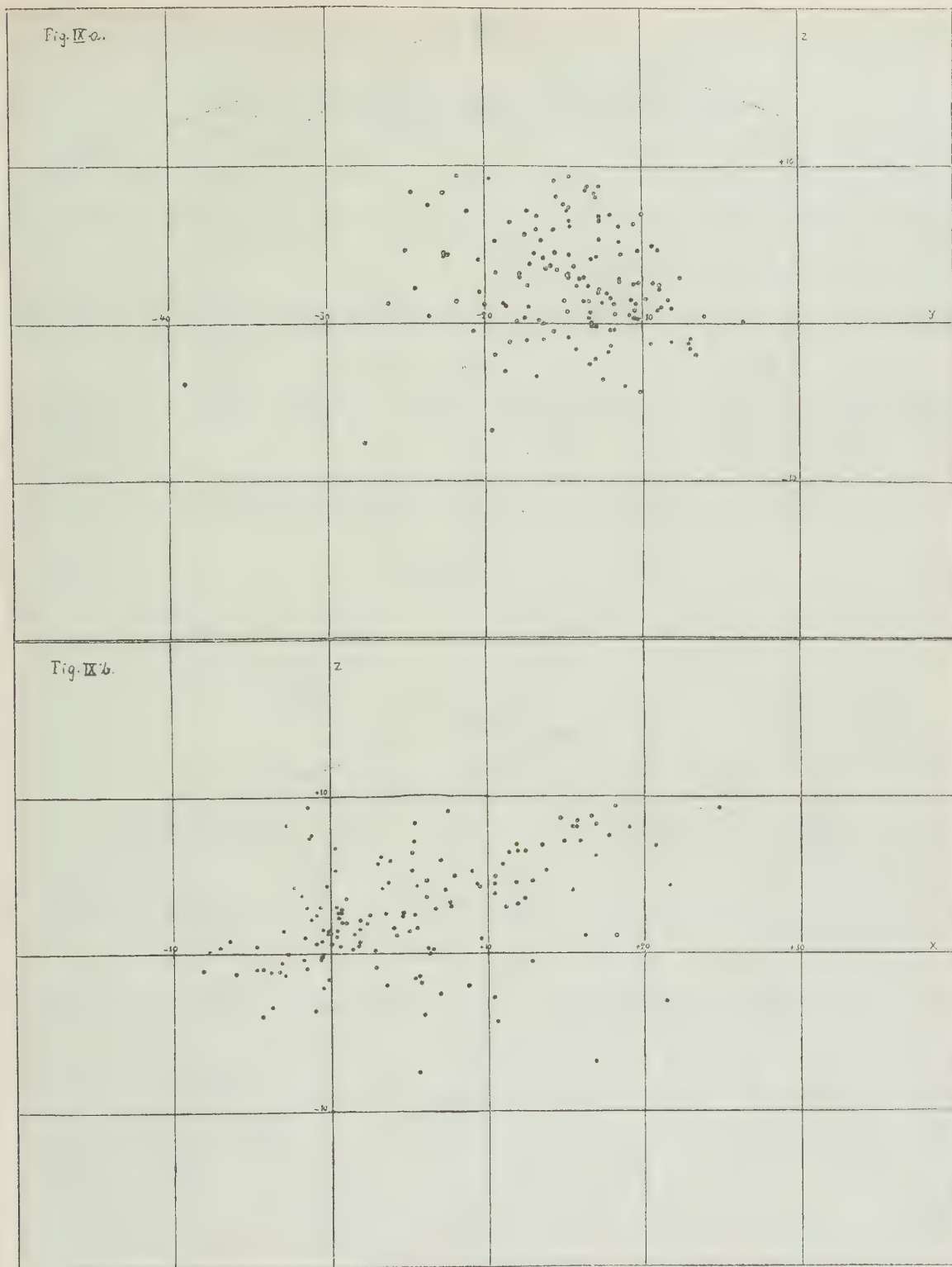


Fig. VIII.

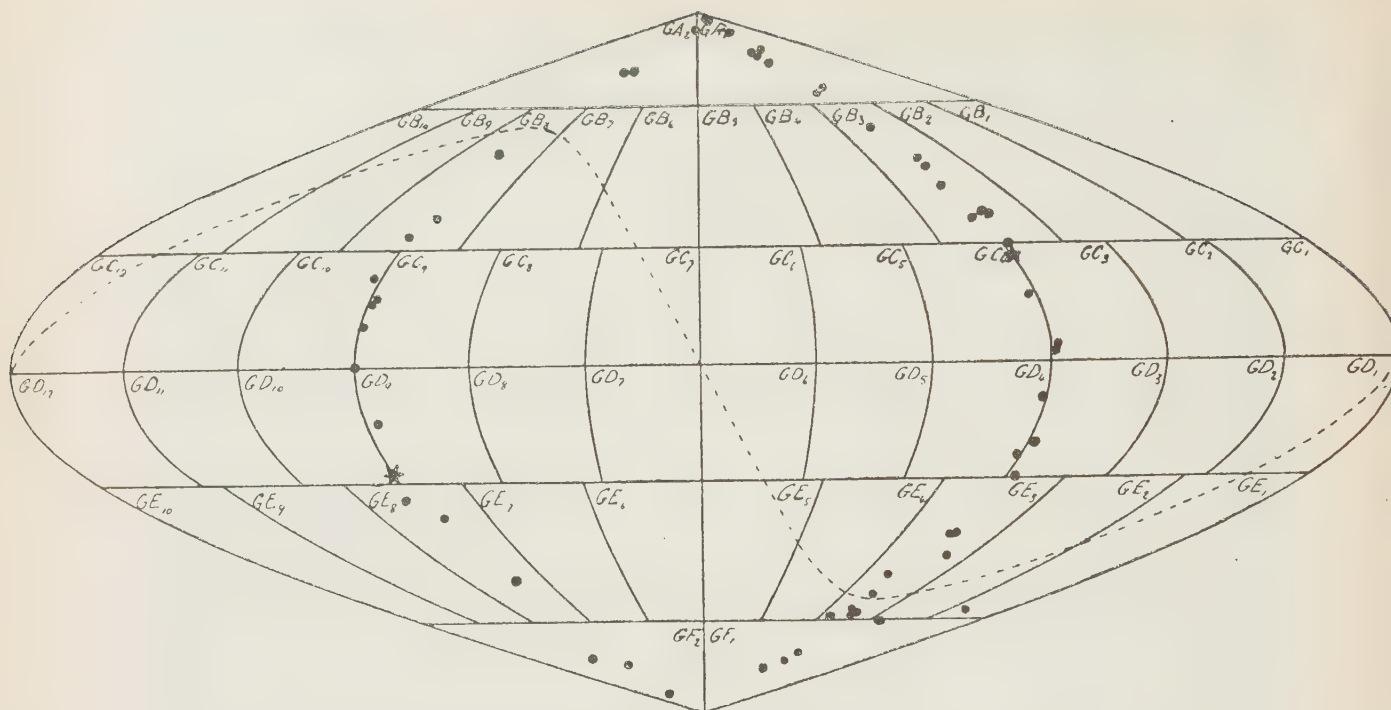
The Scorpio-Centaurus-cluster.

FIG. IX a and b.

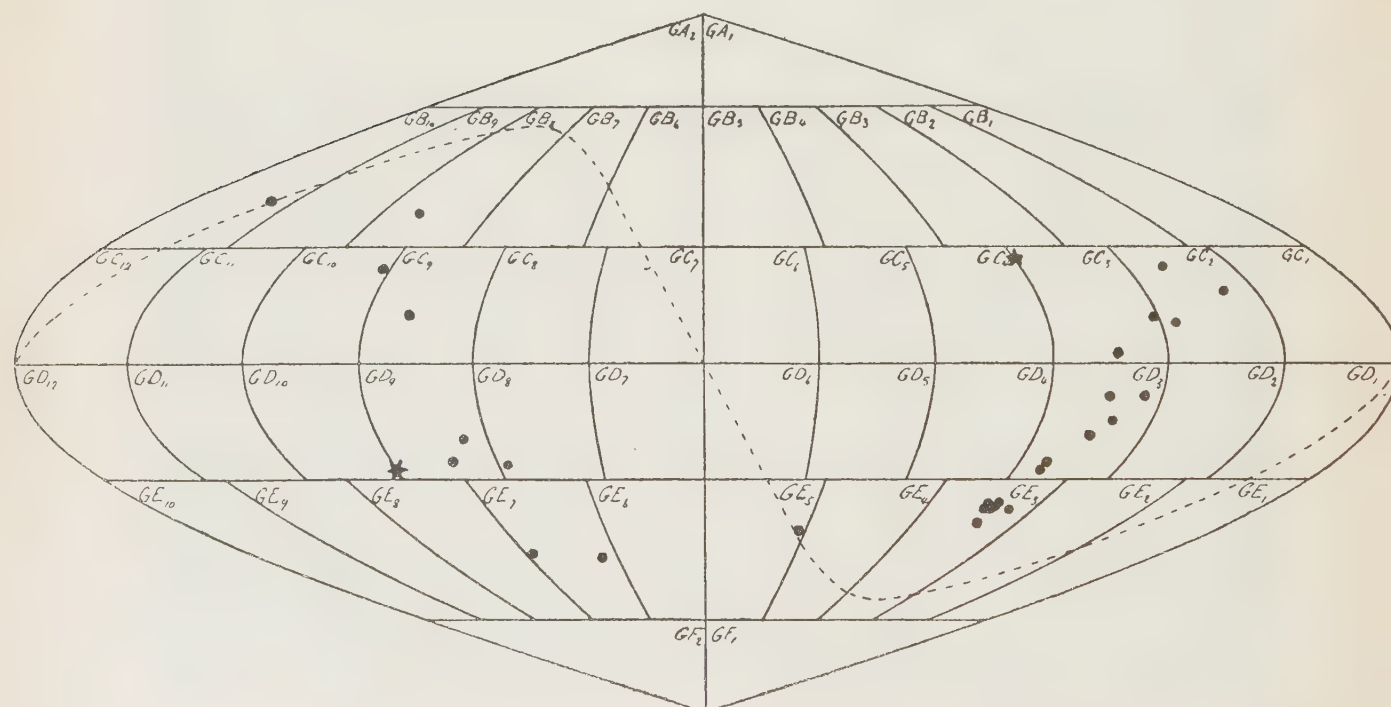


The Scorpio-Centaurus-cluster, distribution in space.

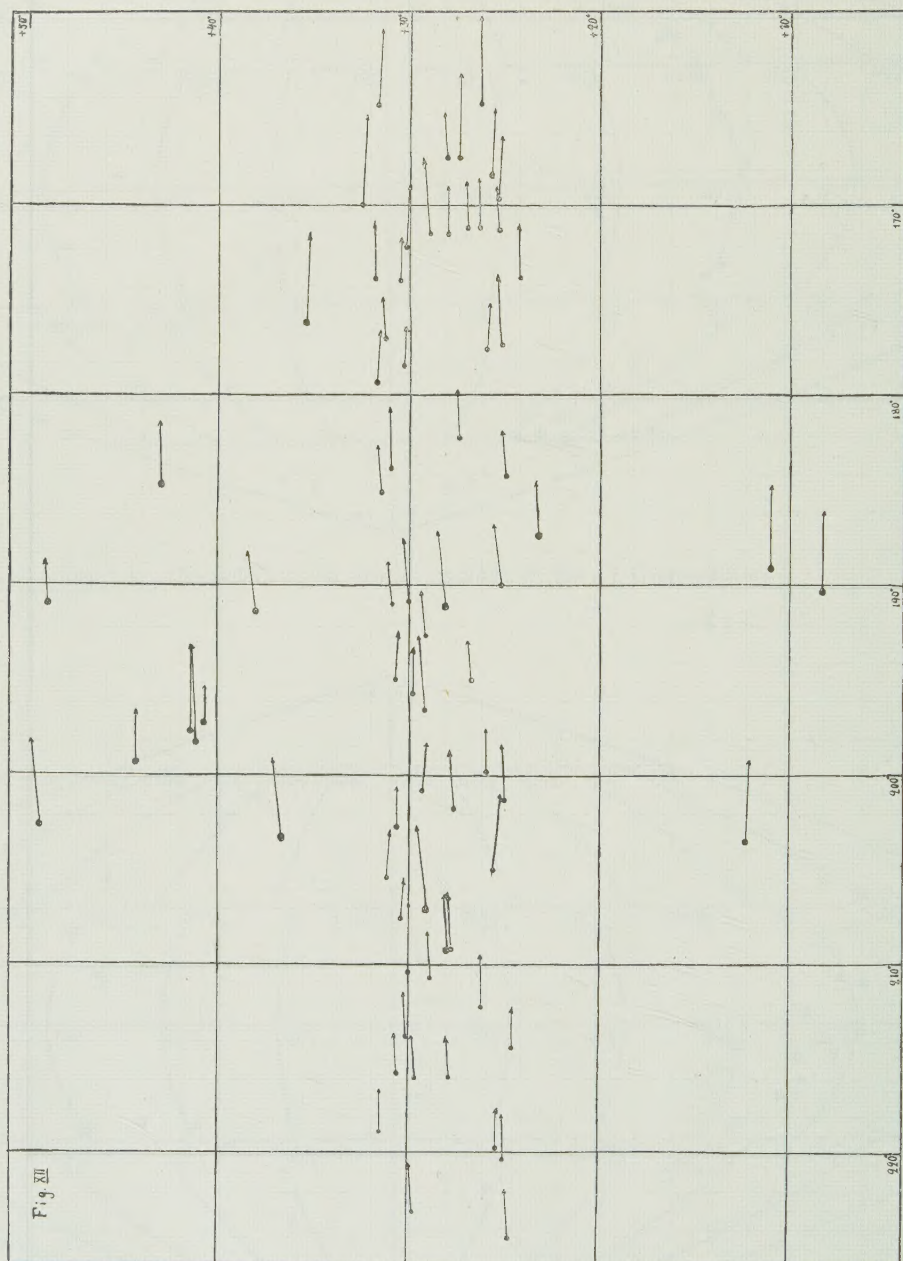
FIG. Xa and b.



(Fig. Xa.) The poles of the proper motions in the 61-Cygni-cluster.



(Fig. Xb.) The poles of the proper motions in the Ursa major-cluster.



The star-streaming in the surroundings of Comæ Berenice.

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